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An extensive study was made of paired-associate learning in children with normal hearing and with severe hearing losses in which the material has been presented auditorily, visually and audio-visually and in which meaningfulness and verbalness have been varied. The conclusion which emerges is that "meaningfulness" is the most important variable that was manipulated. The most surprising finding in the research was the lack of influence of verbalness upon the results. However, since intra-list similarity and discriminability were not controlled experimentally, further research is needed before final assessment can be made of the relative importance of these variables.

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VERBAL AND NONVERBAL LEARNING IN CHILDREN INCLUDING THOSE WITH HEARING LOSSES

Cooperative Research Project No. 1001

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Wayne State University

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Martin served as Project Supervisor for most of the project. Allen, Guenther, and Martin wrote the original drafts of the experiments. Credit is due to Jerry Olson for the preparation of most of the figures.

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INTRODUCTION

The problem under investigation deals with auditory, visual, and audio-visual presentations of material to be learned by children. More specifically, it is concerned with determining if and when a combined audio-visual method of presentation is superior to either an auditory or a visual presentation alone. A full understanding of the efficiency of learning in normal children under these three methods of presenting material has important bearing upon the methods used in teaching children who are hard-of-hearing and deaf.

The literature contains many reports of studies in which an auditory method of presentation has been compared with a visual method and even a number of studies in which the combined method of presentation has been utilized. The results of these studies are not in good agreement; it is likely that at least part of the disagreement is related to the type of material used and to the age of the subjects studied.

In the education of hard-of-hearing and deaf children, it has been assumed that the use of amplified auditory stimulation would accelerate the learning of speech and language and thereby the entire academic progress of the children. As a result, most schools for aurally handicapped children are equipped with electronic apparatus for doing auditory training and for presenting academic material through audition and vision. However, there has been little basic research carried out to determine how best to utilize auditory training with hard-of-hearing children and even little basic research on how normal children use audition and vision in various learning tasks. In a doctoral study, Graunke (1959) compared the learning scores on a paired-associates list learned through vision alone with the learning scores obtained when a comparable list was presented with audition and vision used in combination. He found that the combined presentation was not superior to the visual presentation and that, under certain circumstances, the combined presentation might actually be less efficient.

In 1957 a three year study of verbal learning in children using auditory, visual, and audio-visual presentations was initiated. A large number of children with normal hearing and children with varying degrees of hearing losses were tested on several tasks. The results of the study revealed that, when meaningful material was used with children with normal hearing, there was little difference in the performance scores that could be related to the sensory method of presentation. At that time it was thought that the highly meaningful character of the material used might have obscured differences related to sensory methods of presentation.

The problem under investigation continues to be the study of paired-associate learning using auditory, visual, and audio-visual methods of presentation. The plan of the present investigation was to extend the scope of the material to be learned to include nonmeaningful and nonverbal material as well as to extend the age range of the subjects. It was hypothesized that the study of the learning of nonmeaningful and nonverbal material would highlight differences between unimodal and bimodal presentations. Furthermore, it would appear to have more direct relationship to the learning problems of the hard-of-hearing and deaf who are constantly faced with the task of acquiring a new vocabulary without the benefit of prior and incidental auditory exposure to the items.

OBJECTIVES

The general plan of the investigation was to conduct a study of paired-associate learning when meaningfulness, verbalness, and sensory channel of presentation were varied. The subjects were to be children in the age range from about three through sixteen years.

The analyses of the data were expected to provide answers to the following types of questions:

1. When viewed year by year, does the performance on all types of paired-associate learning improve throughout the school years?
2. Is the evidence that children above the third grade perform equally well whether the material is presented auditorily, visually, or audio-visually, limited to meaningful-verbal material?
3. Does the superiority of an auditory presentation hold in the lowest grades when the material is not meaningful nor verbal as it did for meaningful-verbal material?
4. Does the use of nonverbal and nonmeaningful material support the earlier hypothesis that the child tends to respond to paired-associate material either visually or auditorily but not bimodally?
5. What are the effects of shifting the subject from one sensory learning channel to another within a task?
6. Are the differences which occur in the performances of hearing-handicapped children when meaningfulness and verbalness are varied consistent with those obtained when the material was meaningful and verbal?

RELATED RESEARCH

The present investigation is a direct outgrowth of Cooperative Research Project #289 titled, Verbal Learning Among Children With Reduced Auditory Acuity, (Gaeth, 1960). At the time that research was initiated a review of the literature utilizing auditory, visual, and combined audio-visual methods of presentation revealed considerable disagreement on the efficiency of the three methods. No studies were discovered in which the auditory, visual, and combined methods of presenting paired-associate word lists had been varied systematically using laboratory apparatus. Reference was made to illustrative research carried out on hard-of-hearing and deaf children to study the efficiency of a combined audio-visual presentation of material to straight visual presentations. Johnson (1948) found that the group of children who had had the benefit of auditory stimulation in addition to lip reading was superior in the reception of oral communication, in language facility, and in educational achievement. A joint project carried out by the Central Institute for the Deaf and the Clarke School for the Deaf (Hudgins, Silverman, and Harrison, 1957) reported the following illustrative findings:

> The evidence is clear that the combination of lip reading and hearing is nearly always more efficient than lip reading alone.
>
> ...not only is speech perception improved by the auditory training program, but, in addition, speech intelligibility itself undergoes a gradual improvement under this program.
>
> ...an improved language development and a richer quality in general educational achievement.

About 1952, Graunke (1959) initiated a doctoral study under the direction of the principal investigator of the present research. The purpose of Graunke's study was to compare the efficiency of a combined audio-visual method of presentation to a visual method. A standard memory drum designed for paired-associate learning was used synchronously with an amplified pronunciation of the words from a magnetic tape recorder. Six groups of children, twelve per group, learned one list visually and a second list audio-visually. Lists, method of presentation, and order were counterbalanced for the study. As a result of the investigation, Graunke concluded in part as follows:

> The simultaneous presentation of test materials through two sensory channels did not emerge as a superior condition for learning, and the multi-channel presentation was probably inferior in several of the circumstances under investigation.... These data, therefore, lead one to conclude that the introduction of the auditory stimulus simultaneously with the visual in this type of learning task tended to interfere with the process of memorization.
>
> The results suggest that children with impaired hearing who have potential for substantial use of the auditory modality may experience some inhibition of efficiency when this modality is brought into play as a supplement to memorization of visually presented materials.

Graunke cautions against a generalized interpretation of his results when he states, "The practical implications of the study are restricted to simple tasks of rote learning such as used here."

Also cited in the report of 1960 were certain statements made by Wedenberg (1954), who had utilized auditory training with severely hard-of-hearing children over a number of years. Wedenberg stated:

> The complete or partial loss of the auditory sense results in an even greater concentration of the attention of the other senses and an intensification of their use. The unimpaired visual sense appropriates the greater part of the attention

> to the detriment of the impaired auditory sense. The residual hearing which exists is not rationally utilized.... It is necessary to diminish the visual impression in order that the auditory stimuli may exercise a first claim upon the conscious....

As already mentioned, the present project is a direct outgrowth of the cooperative research study completed in 1960. Because of the close relationship of that study and the present study, the earlier project is reviewed in some detail.

The primary purpose of the first study was to investigate the relationships between performances on rote learning tasks and the sensory method of presenting the tasks. The methods of presenting the paired-associate lists were auditory, visual, and combined audio-visual. Nine sub-conditions were used in which groups of subjects learned two lists, the first presented by one of the three methods and the second presented by the same or a different method. The subjects were normal and hard-of-hearing children in several age groups. Basically, the study was designed to determine if the sensory presentation method affected the rate of learning, if the method of presentation affected retention, if learning an original list via one method of presentation affected the learning on a second list presented either by the same sensory method or by a different one, and if the performances of hearing-handicapped children were significantly different from the performances of normal-hearing children.

The test materials consisted of lists of paired stimulus and response words. For the main part of the study these word lists were constructed using three to five letter monosyllabic words not above the fourth-grade reading level. Several of the lists were standardized for equivalence of performance when presented through either audition or vision.

Three basic pieces of apparatus were assembled to present the lists of word pairs to the subjects. A Patterson memory drum was used for the visual condition. An Ampex, Model 601, tape recorder with a headset was used for the auditory presentation. An Ampex, Model 601-2, tape recorder and an original electronic memory drum were used for the combined condition. The electronic drum was controlled by tone signals recorded on one half of the magnetic tape; the paired-associate words were recorded on the other half. With this apparatus the visual and the auditory components of the combined method of presentation were always synchronous. In one part of the study a group learning situation was utilized, in which the lists were presented visually from a slide projector and auditorily from the Ampex tape recorder and a speaker.

The subjects in the study were children from the schools in the Detroit Metropolitan area. Normal-hearing subjects were selected from the second, third, fourth, fifth, sixth, seventh, and tenth grades. Hard-of-hearing subjects in the same grade range were selected in five hearing-loss categories; viz., 16-30, 31-45, 46-60, 61-75, and 76-90 dB. All subjects were naive with regard to the verbal-learning task. Testing was conducted individually except for one group experiment, and learning of the paired-associate lists was by the anticipation method. In all, a total of approximately 2500 subjects was used throughout the course of the project.

The main conclusions drawn from the study were as follows:

1. The combined method of presentation did not emerge as the superior method.

2. There was some evidence that changing the method of presentation between two lists resulted in poorer performance with the second list when the first list was learned visually and the second list auditorily. This was not found to be true when the first list was learned auditorily and the second visually.

3. There was general improvement in the performance on the tasks from grade to grade from the second to the tenth grades, although most adjacent grades and grades four through ten were not significantly different from each other.

4. The grade by condition interaction was significant: grades 2 and 3 performed poorest on the visual presentation while the highest grades tended to perform about equally well on all the conditions.

5. Using the combined and visual methods of presentation, the hard-of-hearing subjects performed about as well as the children with normal hearing.

6. When the lists were presented auditorily to the hard-of-hearing subjects, the performances were poorer than had been expected. Subjects in the two groups with the least hearing were unable to learn the lists, and the subjects in all groups required the greatest number of trials to learn the lists under this condition.

7. There was no evidence that the performances of the hard-of-hearing subjects were better with the combined method of presentation than with the visual condition.

8. Retention scores were not significantly different among the conditions, the grades, nor between the hard-of-hearing and normal-hearing subjects. This finding was probably to be expected since all subjects learned the lists originally to the same criterion.

In summary, in an extensive study of paired-associate learning with meaningful-verbal material, it was not possible to demonstrate that a simultaneous, combined audio-visual presentation was superior to a visual or an auditory presentation alone. Since this conclusion was based upon data gathered while using meaningful-verbal material that already was thoroughly familiar to the subjects, it seemed likely that differences, which might have been related to the sensory method of presentation, became obscured. In the design of the present investigation it was planned to vary meaningfulness and verbalness systematically in an effort to test this inference.

The studies just described provide the general background for the present investigation. However, there is other research which relates more directly to some of the experiments carried out during the past three years. These investigations are referred to in the individual experiments themselves.

APPARATUS, TEST MATERIALS, SUBJECTS, AND PROCEDURES

In general, the same experimental plan and apparatus were used for each of the experiments. The standard procedures are described in this section; where modifications were made, they are mentioned in connection with the individual experiments.

A. Apparatus

The basic apparatus included a tape recorder and a slide projector arranged so that paired-associate material could be presented auditorily, visually, or audio-visually to groups of children. The visual part of the apparatus consisted of a Bell and Howell, Model 750, 2x2 automatic slide projector, a projector activator, and a 50x50 screen. The projector activator was designed in such a way that it would amplify a signal carried on the tape recorder sufficiently to operate a sensitive relay and thereby close the switching circuit and activate the slide-changing mechanism of the projector. The apparatus for the presentation of the auditory component consisted of an Ampex, Model 601-2, tape recorder, a Fisher, Model 20-A, 15-watt amplifier and an eight-inch loudspeaker mounted in a portable cabinet. The magnetic tape used with the two channel Ampex tape recorder provided the auditory stimuli directly and the control of the visual stimuli indirectly. At the time that the auditory test material was recorded on one half of the tape, short bursts of a high frequency tone were recorded at appropriate intervals on the other half of the magnetic tape. These bursts served to activate the slide-changing mechanism so that, when a combined presentation was desired, the slide showing the visual material would appear on the screen simultaneously with the spoken stimulus from the loudspeaker. Thus, both the visual and the auditory material were programmed from a single magnetic tape and the tape recorder. Once appropriate tapes were prepared, there was no problem of synchronization between the auditory and the visual presentations. During a combined presentation both the auditory and the visual components were in operation. For a visual presentation, the loudspeaker was turned off; for an auditory presentation, the projector activator was disconnected.

B. Test Materials

One of the major goals of the present study involved a description of the relationships among the learning scores for material which varied along the meaningfulness and verbalness dimensions when presented auditorily, visually, or audio-visually. A first step in the development of the study was to establish operational definitions for the meaningfulness and verbalness dimensions and to select material that appeared appropriate to these dimensions.

The distinction between verbal and nonverbal material was specified on the basis of whether or not a given stimulus elicited a pronounceable label. For the purposes of the present study the following types of material represent differences along the verbal dimension: (1) The word "gun" is verbal. (2) The syllable "kez" was considered about equally verbal even though it is less familiar. (3) The syllable "jzx" is much less verbal since it is not easily pronounced as a unit; however, the units are familiar and it can be spelled orally. (4) The symbol "-" is basically less verbal than the preceding three items except that it is a highly familiar symbol which would be likely to elicit the words "hyphen" or "dash". (5) The symbol "<" was considered less verbal than the "hyphen" for the reason that fewer people would recognize the symbol and have available an oral response. (6) An abstract line drawing that was completely unfamiliar would be nonverbal, in that it could not have a single, or coherent multiple, label.

Meaningful versus nonmeaningful material was defined as material which tended to elicit associations as compared to material which did not. In reconsidering the six examples presented under the discussion of verbalness, it is apparent that the distinction between meaningfulness and verbalness is not mutually exclusive. The word "gun" is also the most meaningful of the six items. However, the symbols "-" and "<" are likely to be more meaningful than the syllable "jzx". In spite of this realignment of the items, it is clear that there is a good deal of interrelationship between the two variables.

Originally, it was assumed that the verbalness and meaningfulness variables could be combined into four different types of materials; viz., meaningful-verbal (MV), nonmeaningful-verbal (NMV), meaningful-nonverbal (MNV), and nonmeaningful-nonverbal (NMNV). Lists of materials were prepared for the MV, NMV, and NMNV categories. These materials are described in the following paragraphs. No logical set of material for the meaningful-nonverbal condition was found. Therefore, attempts were made to generate such material experimentally. The results of this attempt are described in Experiment I.

1. Nonmeaningful-nonverbal. Ten visual symbols were created by using the electric and electronic templets which are available with the Leroy sets. Each symbol was generated so that it had two components and so that it appeared to have low associative value to the experimenters. The ten symbols were presented to a college class with the instruction that the students in the class were to write down any label that they felt could be applied to the symbols and to put down any associations which they made to the symbols. The items produced only very indirect associations, and none produced discrete labels. The six symbols finally used are shown in Table 1 in Section 6.

The auditory signals were produced by utilizing the audio-generating, switching, and modulating equipment available in the laboratory of the Hearing Clinic. Specifically, the six noises were produced as follows:

a. A white noise, which was simply recorded from a Grason-Stadler Speech Audiometer, Model 162.

b. A 15 cps square wave, produced by a Hewlett-Packard, Model 202A, Low Frequency Function Generator.

c. A 400 cps tone produced by a General Radio Oscillator, Model 1374, with 5 cps triangular modulation into a reactance tube added to the fixed oscillator.

d. An interrupted 500 cps square wave with 30 msec "on-time" and 30 msec "off-time".

e. An interrupted 1000 cps square wave with 18 msec "on-time" and 240 msec "off-time".

f. Alternating 250 and 500 cps tones, with the 250 cps tone on for 24 msec, a delay of 80 msec, the 500 cps tone on for 90 msec, and a delay of 80 msec.

2. Nonmeaningful-verbal. Three-letter nonsense syllables were selected from Glaze's list (1928). Items were chosen that fell below the 10% level on his lists, that were reasonably pronounceable, and that

contained a minimum of repetition of letters. The six syllables used were: DAQ, KEZ, JID, WOJ, ZEG, and WUB.

3. Meaningful-verbal. Three-letter monosyllabic nouns, which were assumed to be highly familiar to children three years of age or older, made up these stimulus items. They were: GUN, ICE, ARM, SKY, RUG, and CAT. In addition to high familiarity, the items were chosen because they had a minimum of repetition of letters.

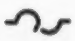
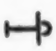
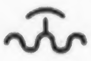
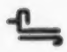
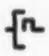
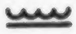
4. Stimulus labels. In the present report, the Arabic numeral subscripts, "1", "2", or "3" are used to refer to nonmeaningful-nonverbal, nonmeaningful-verbal, and meaningful-verbal material, respectively. The capital letters "A" or "V" are used to indicate the sensory channel through which the material was presented. Thus, A_1 represents nonmeaningful-nonverbal material presented auditorily, V_2 represents nonmeaningful-verbal material presented visually, and A_3V_3 indicates meaningful-verbal material presented bimodally.

5. Response items. The letters F, H, L, M, V, and X, were used as the response items. Letters were chosen as response members rather than words or syllables for two reasons. First, the intent was to vary the meaningfulness and the sensory channel of presentation of the stimulus member while holding the response item as constant as possible. Letters of the alphabet appeared to be ideal in that they were highly familiar to the subjects and more likely to have constancy among the subjects than any particular set of simple words that might be chosen. Second, in a group learning situation it is necessary that the response members be written. Single letter responses require a minimum of time and effort.

The six letters were selected on the basis of their visual and auditory characteristics rather than upon the frequency of their occurrence in written or spoken language. Since it was planned that the majority of the subjects to be used in the study would be at the third grade level or above, it was assumed that any letter of the alphabet would be adequately familiar to all subjects. It was arbitrarily decided to use only consonants and to select those that looked and sounded the least alike. To minimize visual confusion "M" was used, but not "N" or "W". Likewise, since "V" was used, letters such as "C", "D", or "Z" were not used because of their rhyming characteristics.

6. Stimulus-response pairings. The same stimulus and response pairings were used throughout the study. These pairings are given in Table 1.

Table 1. Stimulus-response pairings

		Stimuli		Responses
A_1*	V_1	A_2 and V_2	A_3 and V_3	
a		WUB	CAT	H
b		KEZ	ICE	M
c		JID	ARM	V
d		DAQ	RUG	L
e		WOJ	SKY	X
f		ZEG	GUN	F

*The letters refer to the stimuli in the order described in Section 1.

7. Preparation of master tapes. A console-type Ampex, Model 300, two-channel tape recorder was used to record the master tapes. The tapes were prepared specifically for use with a Bell and Howell, Model 750, slide projector. An activating signal for the projector was recorded through one channel of the Ampex tape recorder to one half of the magnetic tape, while simultaneously the auditory stimulus and response items were recorded through the other channel on the other half of the magnetic tape. The activating signal was an 8000 cps pure-tone which was switched and timed by a pair of Grason-Stadler electronic timers and switches. The timers and switches were adjusted so that a 300 msec burst of the 8000 cps tone was passed every four seconds. Timing for the recording of the master tapes was thus provided by the electronic timers and switches. The activating signal was connected from the input monitoring jack of the tape recorder to the projector activator, and thus the projector was put into operation at the time of the recording. Slides containing the visual materials were put into the slide trays, and projected through the viewing window into an adjacent "soundproof" room. An announcer was seated in the "soundproof" room with a microphone connected to the input of the other channel of the master tape recorder. With appropriate practice, the announcer was able to record the auditory component simultaneously with the visual projection from the slide projector. For the nonmeaningful-nonverbal auditory noises, the appropriate burst of noise was switched on for the duration of the visual presentation of the appropriate material.

The study was designed for ten test and ten learning trials per condition. Therefore, a learning trial was recorded followed by a test trial, and so forth until a total of ten of each had been completed. Three separate random orders of the materials were used for the test trials and for the learning trials. During a learning trial, the stimulus slide was projected for about 2.5 sec. followed immediately, allowing for the latency of the changer mechanism, by the response slide. The response slide was also presented for about 2.5 sec. There was an interpair interval of about 5 sec. before the next pair, et cetera. During a test trial, only the stimulus items were presented. The stimuli were each presented for 2.5 sec. with an interval of 5.5 sec. between items. During the period of time that the stimulus item was being projected and the ensuing 5.5 sec., the subjects wrote down the appropriate response item if they had learned it.

Three master tapes were prepared. One contained the meaningful-verbal material and the six letters of the alphabet as response items, the second contained the nonmeaningful-verbal material and the same six letters of the alphabet as response items, and the third carried the nonmeaningful-nonverbal noises and the response items.

C. Subjects

As mentioned previously, almost all the testing for the project was done in group situations. The main body of data was gathered from grades 2, 3, 4, 5, 6, 7, 8, 10, and 12. These children were in regular public schools and an entire class was tested simultaneously. For kindergarten and first grades, the size of the group was limited to about ten. Hard-of-hearing and deaf children were tested in groups of four. In the case of the younger children, the size of the group was limited in order to insure adequate attention, understanding of instructions, and monitoring of the tasks while in progress. The size of the groups for the hearing-handicapped children was limited to four because the apparatus was built to function with four headsets and intensity controls.

The assignment of subjects to conditions was accomplished as follows: Before a specific experiment was started, the numbers of conditions, grades, and classrooms of children needed to complete the experiment were determined. Then a member of the research staff met with a member of the staff of the Research Division of the Detroit Public School System. The two of them agreed upon a group of schools, which were neither in the poorest nor in the best neighborhoods, and these schools were contacted and requested to cooperate in the project. Once the number of classrooms involved and their locations had been established, the researchers on the project assigned conditions to classrooms at random. More specific details on the utilization of subjects and the sizes of the samples are presented in connection with the individual experiments in the Results Section.

In the collection of the data which culminated in the report of 1960, all subjects used were given hearing and vision screening tests prior to being used as subjects. The experience with that procedure indicated that such screening was not essential to the conduct of the research. Instead, as part of the instructions and demonstration, the children were asked whether they could see or hear the stimuli that were being presented. When an occasional child expressed difficulty, note was taken of the number of his answer book and it was later decided whether to exclude it or include it in the analyses. Throughout the course of the experiments, there were a few children who made no correct responses during the ten trials; the answer booklets from these children were omitted. Other than this, the data from all subjects were utilized in the analyses or, in those instances where it was considered desirable to reduce the size of the sample for purposes of computation, the data which were excluded were removed from the pool on a strictly random basis.

D. Procedures

The same general procedure was followed in gathering all the data for the project. Where there were changes in this procedure, they are described in connection with the individual experiments in the Results Section.

Before testing began in a given school, a classroom was selected for test purposes. The classroom was arranged with the screen and loudspeaker in the front of the room and the tape recorder, amplifier, and slide projector all on a table at the rear of the classroom. At least two and usually three experimenters were present for the administration of a test condition. An entire section of a given grade of children was brought into the testing room at one time. One experimenter explained the task and the requirements to the children, while a second experimenter passed out the answer booklets. The third staff member operated the experimental apparatus.

For V_1, the children were told that they would see a symbol followed by a letter of the alphabet. They were instructed to learn the letter that went with the stimulus and during test trials to write that letter in the answer booklet. Appropriate changes were made for the other conditions. Very little difficulty was encountered in explaining the task to the children, although there is little doubt that learning to perform the task made some contribution to the lower scores obtained with the younger children.

Response booklets were used with a separate page for each trial. Each page contained numbered blanks in which to write the answers. At the completion of each test trial, the children turned to a new page.

RESULTS

The data gathered for the present project are reported as a series of separate experiments in this section. In general, each experiment represents an independent attack upon some part of the problem. With only slight deviations for simplicity in reporting, the experiments are presented in the order in which they were conducted.

Large numbers of children served as subjects for the project. These children were tested in a group situation in which usually all the children in a section of a given grade were tested simultaneously. In general, ten learning and ten test trials were administered. Each subject's score was the total number of correct responses given during the ten test trials.

Experiment I was concerned with attempts to create meaningful-nonverbal material. Groups of subjects were given differing amounts of experience with the nonverbal-nonmeaningful material and attempts were made to relate the amount of experience with the stimuli to the learning scores. Experiment II was considered an extension of an earlier study using auditory, visual, and audio-visual methods of presentation across grades. Previously, the material had been fully meaningful; in this instance, nonmeaningful-nonverbal material was utilized. Experiment III was the most extensive study. Three levels of meaningfulness and verbalness and three methods of sensory presentation were utilized in all possible combinations. The resulting fifteen conditions were presented in total or in part to children in grades 2 through 12. Experiment IV reports the results of a small study involving the change of the sensory modality of presentation in the middle of the learning task. Experiment V summarizes the results of the use of a limited number of conditions with children in kindergarten and first grade, and Experiment VI gives the results obtained with pre-school children. Experiment VII reports the results obtained with the three visual conditions in a sample of children from a school for the deaf. For Experiment VIII a series of combined and control conditions were presented to samples of children in another deaf population. In this instance, ten trials were presented with the basic combined condition followed by an additional five trials utilizing only the auditory material of the particular combined condition. Finally, a section is included in the Appendix which discusses a series of analyses that were carried out upon the test items utilized throughout the project.

Experiment I

Stimulus Familiarization; Two Conditions; Two Grades

ABSTRACT. Groups of subjects were given varying degrees of familiarization with nonverbal-nonmeaningful stimuli that were later used as the stimulus member of a paired-associate task. The groups of children who were given familiarization trials did not perform significantly better on the learning trials than did children who started to learn without the pretraining.

A. Introduction

One of the major goals of the present study involved a description of the relative ease of learning meaningful-verbal, nonmeaningful-verbal, meaningful-nonverbal, and nonmeaningful-nonverbal materials. The distinction between verbal and nonverbal material was made on the basis of whether a given stimulus would elicit a label or word, and the distinction between meaningful and nonmeaningful material was made on the basis of whether a given stimulus would elicit associations. The combination of these two variables, "verbalness" and "meaningfulness", would produce four different types of materials: meaningful-verbal (MV), nonmeaningful-verbal (NMV), meaningful-nonverbal (MNV), and nonmeaningful-nonverbal (NMNV). The word "gun" is an example of MV material. A nonsense syllable such as "kez" is an example of NMV material in that "kez" is pronounceable but does not tend to elicit associations. A complex geometrical figure would exemplify nonmeaningful-nonverbal material. The only combination that does not yield obvious material is the meaningful-nonverbal combination.

Originally it was thought that meaningful-nonverbal material could be produced experimentally. In order to generate meaningful-nonverbal material it was necessary to re-define the concept of meaningfulness. Underwood and Schulz (1960) have indicated that meaningfulness (M), as defined by the number of subjects who get an association (Glaze, 1928) or as defined by the production method (Noble, 1950), has little to do with the relationship between M and learning which has been observed in a number of studies. Instead they state that the frequency of occurrence of a particular letter unit is more crucial in a definition of M. They arrived at this conclusion by demonstrating a high positive relationship between meaningfulness and percentage of syllables that occur as trigrams in words. Finally, they showed in a portion of their data that frequency predicts rate of learning better than does M as defined by the number of subjects who get an association or by the production method. The frequency attempts at defining M by Underwood and Schulz have been most successful with individual letters and with generated bigrams. Frequency manipulations with nonmeaningful-nonverbal materials have not been reported in the literature to our knowledge.

Pretraining has been shown to influence learning favorably, especially when the pretrained materials are of a "nonverbal" nature. Using such materials, Gagne and Baker (1950), Cantor (1955a,b), and Goss (1953) have demonstrated facilitation on a transfer task as a result of stimulus pretraining. Using verbal materials, Underwood and Schulz (1960) and Cieutat, Stockwell, and Noble (1958) present data which indicate that M has a greater effect on the response side in the paired-associate paradigm than on the stimulus side. The present experimenters do not have knowledge of a study using verbal materials which shows clear-cut effects of stimulus pretraining.

Pretraining given on NMNV stimuli prior to the paired-associate learning task is an appropriate condition satisfying a definition of meaningfulness based upon a concept of frequency. If NMNV stimuli are then presented in a paired-associate learning situation, it may be argued that as a result of this pretraining the stimuli may be described as MNV. The validity of this approach would be enhanced if it showed that stimulus pretraining has facilitative effects upon subsequent paired-associate learning.

However, an additional interpretation of facilitative effects of pretraining might be considered. Pretraining might be considered to be effective only insofar as it leads to necessary differentiation of the stimuli. This position has recently been outlined by Saltz (1963). He states that differentiation progresses as a function of (pretraining) trials and serves to decrease interfering stimulus and response generalization.

The purpose of the present experiment was to develop MNV material and to determine the relationship between the amount of stimulus pretraining and the ease of learning paired associates. It was also hoped that additional insight into "pretraining" as a theoretical construct and its relationship to the constructs "meaningfulness" and "differentiation" could also be gained.

B. Experimental Procedures

1. Subjects. The subjects in Experiment I were 152 sixth-grade and 121 fifth-grade children who were enrolled in regular classes in

the Detroit Public School system.

2. Materials. The stimuli consisted of the visual nonmeaningful-nonverbal (V_1) and auditory nonmeaningful-nonverbal (A_1) materials.

3. Procedure. Slightly different methods of familiarization were used for the two sets of materials. For the auditory familiarization, five groups of sixth-grade subjects were given either 0, 3, 6, 9, or 12 familiarization trials on the A_1 material. The six stimuli were presented in three random orders. Each stimulus was presented for 2 sec. with 4 sec. between each presentation. The inter-trial interval was approximately 20 sec. There were 30, 34, 30, 29, and 29 subjects in the 0, 3, 6, 9, and 12 familiarization trial groups, respectively.

For the visual familiarization, four groups of fifth-grade subjects were given either 0, 6, 9, or 12 familiarization trials on the V_1 material. There were 34, 32, 26, and 29 subjects in the 0, 6, 9, and 12 familiarization trial groups, respectively. The intra- and inter-trial intervals were 4 and 20 sec. respectively and the stimulus duration was 2 sec. At the end of every third trial the subjects were given two minutes in which to draw from memory as many of the six stimuli as possible.

At the completion of the pretraining session, the instructions for paired-associate learning were given and the standard procedure was used.

C. Results and Discussion

1. Auditory Familiarization. The means and standard deviations of the number of correct responses for the 0, 3, 6, 9, and 12 trial familiarization groups are presented in Table 1.1. A simple randomized

design was used to evaluate the mean number of correct responses during the ten trials on the paired-associate task for the 5 sixth-grade auditory familiarization groups. The resulting F value of 1.82 (df = 4/147) was not statistically significant ($p > .05$). Figure 1.1 (p. 30) presents the learning curves for the five groups on the paired-associate learning task.

These results show that stimulus pretraining on unfamiliar nonverbal auditory stimuli has no effect upon subsequent S-R learning where the auditory stimuli are used as S-terms in a paired-associate list. The difficulty with this pretraining procedure was that there was no simple technique of assessing the extent to which the subjects had attended to the auditory stimuli during the pretraining trials. It might be argued that since the pretraining task had made no demands upon the subjects that they had either attended minimally or not at all.

Table 1.1. Means and standard deviations of the number of correct responses, by auditory familiarization groups.

	Stimulus Familiarization Groups				
	0	3	6	9	12
$\bar{X}$	27.90	30.41	27.80	24.55	32.90
s	10.20	12.67	14.09	13.31	12.31
N	30	34	30	29	29

2. Visual Familiarization. In order to have some measure indicative of the degree of familiarization that had been achieved during the stimulus pretraining sessions, the subjects were required to draw from memory the six V_1 stimuli after every third trial. Table 1.2 presents

the mean number of correct stimuli drawn after every third familiarization trial by the groups who had a total of 6, 9, and 12 visual familiarization trials.

Table 1.2. Mean number of V_1 stimuli drawn correctly after every third familiarization trial.

Familiarization Trials	Stimulus Familiarization Groups 6	9	12
3	2.78	2.42	1.75
6	3.60	4.38	2.84
9		4.54	4.22
12			4.73

A simple analysis of variance design was employed in order to analyze the total number of visual stimuli drawn correctly for the 6, 9, and 12 visual familiarization groups. Table 1.3 presents the summary of this analysis.

Table 1.3. Summary of the simple analysis of variance of the number of correct stimuli drawn during the pretraining sessions by the 6, 9, and 12 visual familiarization groups.

Source	df	MS	F
Between	2	479.18	50.32**
Within	85	9.52	
Total	87		

**$p < .01$

The analysis indicated that there was a difference, significant at the .01 level, among the three groups in the total number of correct

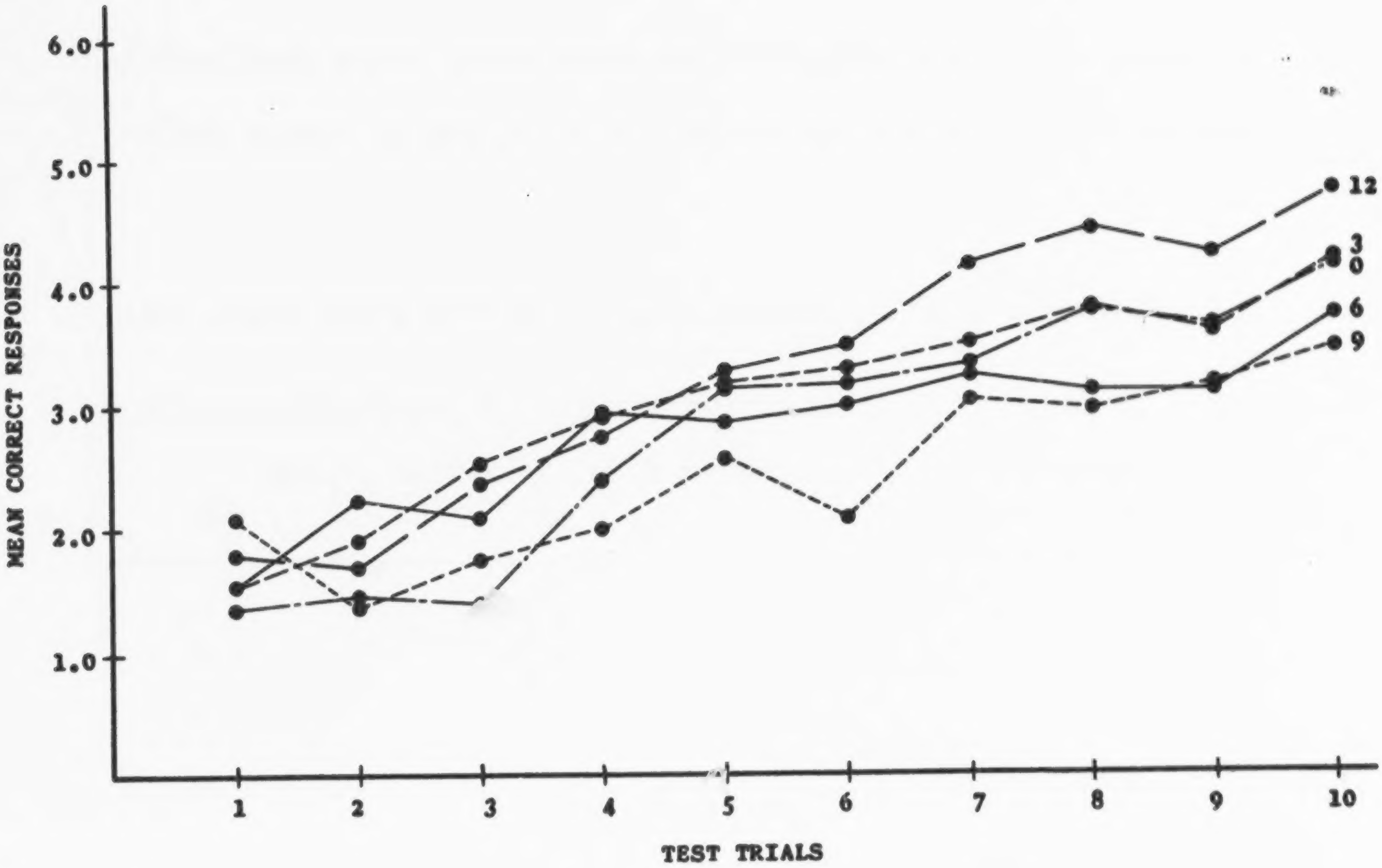


Fig. 1.1 Learning curves for the five familiarization groups, A_1 material.

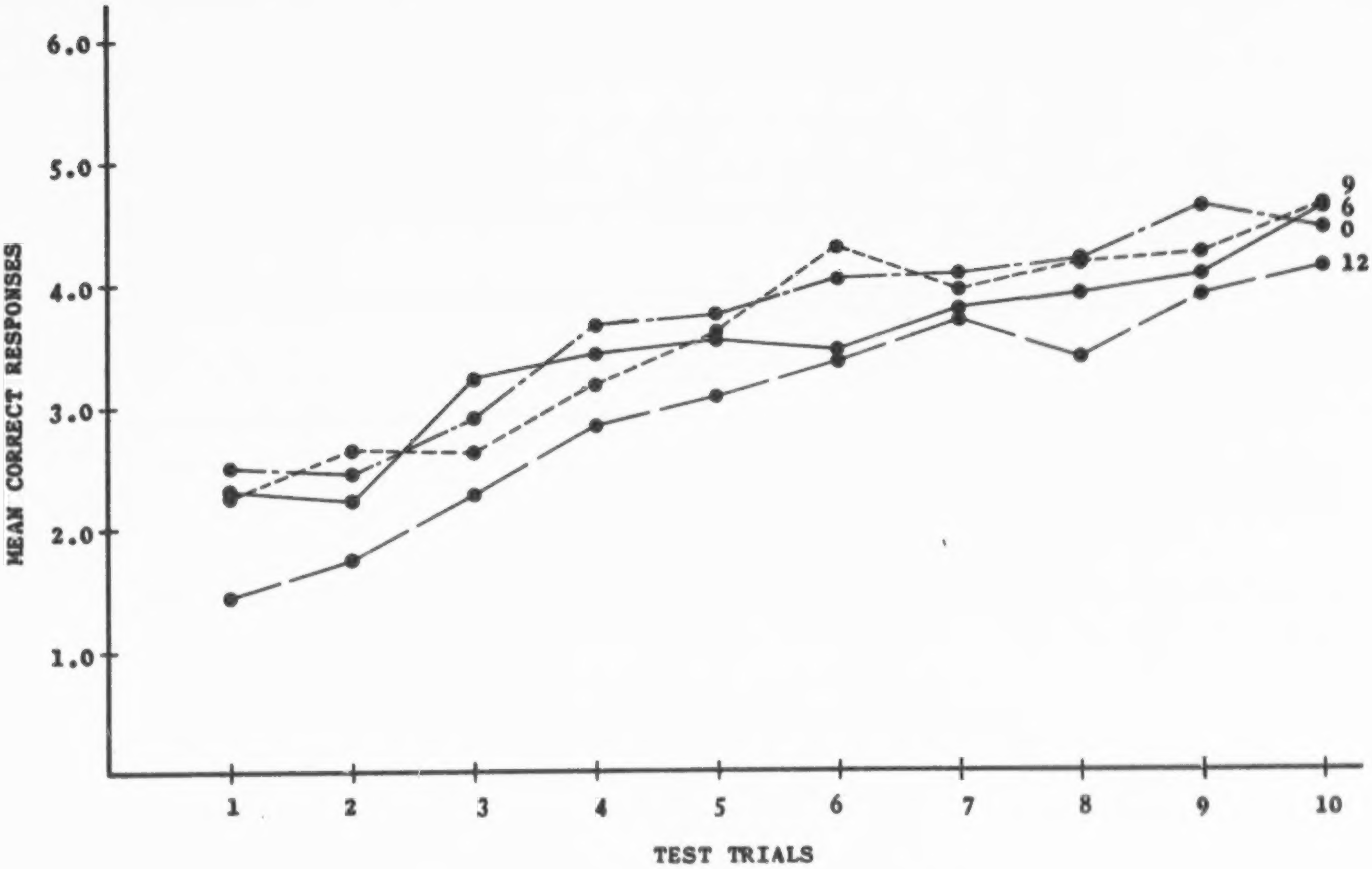


Fig. 1.2 Learning curves for the four familiarization groups, V_1 material.

stimuli drawn. Because of the difference in variance among the three groups, a Kruskal-Wallis (Siegel, 1956, 184-193) one-way analysis of variance was performed on the number of correct stimuli drawn in the three familiarization groups. This analysis yielded an H value of 49.34, which was also significant at the .01 level. These results are indicative of significant differences in the amount of stimulus familiarization among the 6, 9, and 12 visual familiarization groups.

Table 1.4 presents the means and standard deviations of the number of correct responses during the ten test trials on the paired-associate learning task. The data in Table 1.4 were analyzed by a simple analysis of variance design. The resulting F value of 1.37 (df = 3/117) did not approach significance at the .05 level. Figure 1.2 (p. 30) presents the mean number of correct responses for the ten test trials. An inspection of Figure 1.2 and the results of the analysis of the data in Table 1.4 indicates no facilitation in paired-associate learning as a result of familiarization of the S-terms used in the S-R learning task.

Table 1.4. Means and standard deviations of the number of correct responses, by visual familiarization groups.

	Stimulus Familiarization Groups			
	0	6	9	12
$\bar{X}$	36.71	34.50	36.00	30.03
s	15.87	10.71	14.46	14.32
N	34	32	26	29

At the completion of the visual stimulus familiarization trials, the subjects in the 12 trial groups were able to draw correctly an average of 4.73 visual stimuli from a possible total of six. It is surprising that this relatively high degree of familiarization did not produce any subsequent facilitation in the paired-associate learning task when compared to the group that had no contact with the stimuli prior to the learning task.

The present findings do not correspond well with either of two sets of results that have appeared in the literature. Cieutat, Stockwell, and Noble (1958), and Underwood and Schulz (1960) found no improvement due to pretraining; however, they used verbal material. On the other hand, Gagne and Baker (1950), Cantor (1955b), and Goss (1953) utilized nonverbal stimuli and found improvement due to pretraining. It is possible that the present experiment did not show improvement due to the pretraining because a motor task was not utilized as was done in the other research.

One reason for expecting improvement as the result of pretraining stems from the idea that differentiation among the stimuli takes place during this period. However, the stimuli may have been sufficiently unique that the differentiation necessary for learning existed prior to the task or was acquired very quickly. If this were true, then it might be assumed that all subjects were starting almost immediately upon the second "associative" stage in which the S-R connections were building slowly in an incremental fashion. This interpretation would, of necessity, be dependent upon the demonstration that the visual stimuli were differentiated prior to pretraining and that the drawing of the stimuli was not an adequate test of differentiation. Further research is necessary before theoretical implications are drawn from the present results.

On the basis of the data the attempt to generate meaningful-nonverbal material experimentally was abandoned.

D. Summary and Conclusions

Five groups of subjects were given preliminary familiarization varying from 0 to 12 trials, with auditory nonmeaningful-nonverbal material. Four other groups were given similar pretraining with nonmeaningful-nonverbal visual material. No procedure was found for checking on the amount of familiarization produced with the auditory stimuli, but the fact that the subjects were able to draw most of the visual symbols from memory was considered evidence that familiarization had taken place with these subjects. No improvement was found in the learning scores in the groups who had had the familiarization over those who had not had it.

If meaningfulness is a variable which affects paired-associate tasks, familiarization as used here does not produce the appropriate kind of meaningfulness.

Experiment II

Learning in Grades Three through Eight; Three Conditions

ABSTRACT. Nonmeaningful-nonverbal material was presented in paired-associate learning tasks to groups of children in grades 3 through 8 using auditory, visual, and audio-visual methods of presentation. As with meaningful-verbal material, there were no significant differences in the performances between the combined and visual methods of presentation. There was improvement in performance in all three methods of sensory presentation across grades; however, there were some inconsistencies.

A. Introduction

Previous research (Gaeth, 1960) revealed little or no difference in the learning of paired-associate material that could be related to the sensory method of presenting the material. In general, the auditory and visual methods of presentation were equivalent, and the combined audio-visual presentation was not superior. Furthermore, while the performances of the second- and third-grade children were significantly below that of the children in the higher grades, there were no significant differences above the fourth grade although there was a possible trend in the data suggesting slightly better performances. It was assumed that the general absence of significant differences among conditions and among grades has been related to the fact that simple and highly meaningful material had been used. Experiment II was designed to determine whether the same general conclusions would prevail when the test material was neither verbal nor meaningful.

B. Background and Related Research

There is a great deal of experimental evidence to indicate a relationship between meaningfulness of material and rate of learning. Underwood and Schulz (1960) review much of this literature. In general, the results show positive correlations between meaningfulness of material and the rate at which the material is learned in a laboratory situation. This positive correlation between the meaningfulness of the material and the rate at which the material is learned has been demonstrated in both paired-associate and serial-learning situations.

There have been a number of attempts to quantify meaningfulness. One such attempt was made by Noble (1952). He selected 96 dissyllables consisting of nouns and paralogs and presented them to a sample of 119 USAF recruits. The S's were presented the dissyllables and were given 60 seconds in which to write all the different word associations elicited by a particular dissyllable. The M value (meaningfulness) of a given dissyllable was operationally defined as the mean of the written responses given by all S's within the one minute period. Noble's definition of meaning involves the relationship between a stimulus and the responses. He assumes that meaning increases as a function of the number of response connections acquired by a given stimulus during the organism's history. Material that is high in meaning elicits more responses than material that is low in meaning. Theoretically, material that has no meaning does not elicit associations. On the basis of Noble's definition of meaning, it would seem logical to assume that a given unit of meaningful material would increase in meaning as a function of the age of the organism. Within certain unspecifiable limits the older the organism the greater the opportunity for various responses to have become associated to the verbal unit. Therefore, given a certain level of meaningful-verbal material, it would be of interest to be able to specify the relationship between age and rate of learning of this material. Furthermore, it would be useful to know if the relationship between age and rate of learning meaningful-verbal material is the same regardless of the sensory mode of presentation.

In connection with the latter point, the results of several investigations that were concerned with the effects of multi-sensory presentation of learning materials have not been entirely consistent. There is evidence that the aurally handicapped individual receives spoken communication more efficiently when amplification is introduced, thereby creating a combination of lip-reading and audition. However, when some type of verbal-learning procedure is used in order to evaluate the effects of multi-sensory material presentation no such facilitation is observed.

Gaeth (1960) reported that a four word-pair practice list of meaningful-verbal words was learned in significantly fewer trials by normal-hearing subjects when the list was presented visually than when presented auditorily. The combined presentation required an intermediate number of trials and was not significantly different from either the visual or auditory method of material presentation. These results were obtained from a total of 270 normal-hearing subjects from the fourth grade.

With respect to the relationship between age and rate of learning verbal-meaningful material, Gaeth (1960) also obtained results from a total of 300 normal-hearing subjects from grades 2, 3, 7, and 10. The results showed that the second grade required significantly more trials than did the third, seventh, and tenth grades to learn an 8 word-pair meaningful list. The third grade also required significantly more trials than did grades 7 and 10. Again the results did not indicate a significant difference between the auditory, visual, and combined methods of presentation.

With regard to hard-of-hearing subjects, the data based upon paired-associate learning tasks indicate that the combined method does not produce a facilitative effect upon learning. Graunke (1959) found that children with impaired hearing may experience some inhibition in the combined method of material presentation. His results did not show that normal-hearing children experience similar inhibition in the combined method. Gaeth (1960) had 90 hard-of-hearing subjects learn an 8 word-pair list. He found that the auditory condition required significantly more trials to learn than did the visual and combined conditions. The visual and combined conditions were not significantly different from each other. Thus, these results do not give any indication of acceleration in learning due to a combined presentation.

As stated, the purpose of the present experiment was to explore the effect of nonmeaningful-nonverbal paired-associate learning in relation to the method of material presentation and grade placement. If the combined method of presentation had failed to facilitate the learning of meaningful material because fully established concepts were involved, it might facilitate learning when the material was totally unfamiliar. Differences, if observed among grades in rate of learning nonmeaningful-nonverbal material, probably could not be attributed to increasing meaningfulness of the material as grade level increased, because the nonmeaningful-nonverbal visual material was such that the stimuli did not tend to elicit any words or labels among college students. However, one would expect the higher grades to perform better due to increased experience in learning situations. They should have developed more efficient approaches to a learning task, i.e., they have "learned to learn" (Harlow, 1949).

C. Experimental Procedures

1. Subjects. The subjects in this study consisted of 990 children enrolled in regular classes in the Detroit Public Schools. A total of 165 children in each grade were tested from grades 3-8.

2. Materials. The nonmeaningful-nonverbal auditory and visual materials (A_1 and V_1) were used in this study. As mentioned in the original description of the nonmeaningful-nonverbal material, the two lists were generated separately, and no effort was made to create equivalent lists. Therefore, comparisons of modalities may be confounded with list difficulty.

3. Procedure. The nonmeaningful-nonverbal auditory (A_1), visual (V_1), and combined (A_1V_1) paired-associate lists were presented to children in grades 3, 4, 5, 6, 7, and 8. The three types of material: A_1, V_1, and A_1V_1 and the six grades (3-8) result in 18 experimental conditions. Two classrooms of children were used for each condition. Due to the size of available classes, an unequal number of subjects were tested in each of the conditions with the smallest groups consisting of 55 subjects. In order to simplify the statistical analyses, each group was reduced to 55 subjects by randomly eliminating subjects until the sample size was reduced to 55.

D. Results and Discussion

The number of correct responses made per subject during the ten test trials was used as the criterion measure. The means and standard deviations of these scores for the 18 conditions are presented in Table 2.1, and the learning curves, based on all subjects, are given in Figure 2.1 (p. 42). Two results are obvious from inspection of the marginal totals in Table 2.1. There is improvement in performance over grades, and the combined and visual methods of presentation are both superior to the auditory but do not differ from each other.

Table 2.1. Means and standard deviations of the number of correct responses, by conditions and grades.

Grade			Conditions		$\bar{X}$
		Auditory (A_1)	Visual (V_1)	Combined (A_1V_1)	
3	$\bar{X}$	16.54	21.87	24.43	20.95
	s	8.40	10.72	13.00	
4	$\bar{X}$	20.38	19.84	24.15	21.46
	s	10.44	9.67	12.27	
5	$\bar{X}$	21.95	34.93	29.85	28.91
	s	11.47	14.33	13.67	
6	$\bar{X}$	26.18	32.83	34.71	29.67
	s	13.31	13.23	12.72	
7	$\bar{X}$	32.40	36.64	31.87	33.64
	s	13.30	13.23	12.72	
8	$\bar{X}$	34.11	38.24	36.58	36.31
	s	13.09	12.19	13.64	
	$\bar{X}$	25.26	30.72	30.26	

An analysis of variance of the three modalities and six grades was carried out on the data in Table 2.1. Table 2.2 presents the summary of this analysis. Both the differences among grades and among the three methods of material presentation were highly significant. Because the interaction of grades x modality was also significant, direct interpretations of the main effects were not possible. Therefore, a simple analysis of variance for each modality across the six grades was calculated. Table 2.3 summarizes the three analyses of variance. Clearly,

Table 2.2. Summary of the analysis of variance for three modalities and six grades.

Source	df	MS	F
Grades (G)	5	6641.70	43.28**
Modality (M)	2	3029.70	19.74**
G x M	10	446.76	2.91**
Error	972	153.45	
Total	989		

**$p < .01$

Table 2.3. Summary of the three simple analyses of variance of grades for each condition.

Modality	Source	df	MS	F
A_1	Grades	5	2649.48	19.16**
	Error	324	138.31	
V_1	Grades	5	3413.63	22.25**
	Error	324	153.42	
A_1V_1	Grades	5	1472.10	8.73**
	Error	324	168.59	

**$p < .01$

there were significant differences among the grades for each method of presentation.

In an attempt to ascertain which of the grades differed within a given modality, Newman-Keuls (Winer, 1962) tests were applied to the data. The results of these tests are presented in Table 2.4. The scores are arranged by numerical rank, not by grades, and the vertical lines indicate the range of "no difference".

Table 2.4. Results of the Newman-Keuls tests for grades 3-8 for each of the three conditions.

Grade	Auditory	Grade	Visual	Grade	Combined
3	16.54	4	19.84	4	24.15
4	20.38	3	21.87	3	24.43
5	21.95	6	32.82	5	29.85
6	26.18	5	34.93	7	31.87
7	32.40	7	36.64	6	34.71
8	34.11	8	38.24	8	36.58

In the auditory condition, no significant differences were found between adjacent grades except for the sixth and seventh grades. However, all non-adjacent grades differed significantly from each other.

With the visual material grades 3 and 4 were not significantly different from each other, nor were grades 5, 6, 7, and 8 significantly different from each other. However, grades 3 and 4 differed significantly from all higher grades.

The results of the combined conditions indicate that the grade groupings 3, 4, 5; 5, 6, 7; and 6, 7, 8 do not differ statistically within themselves, while grades 3 and 4 are both lower than grades 6

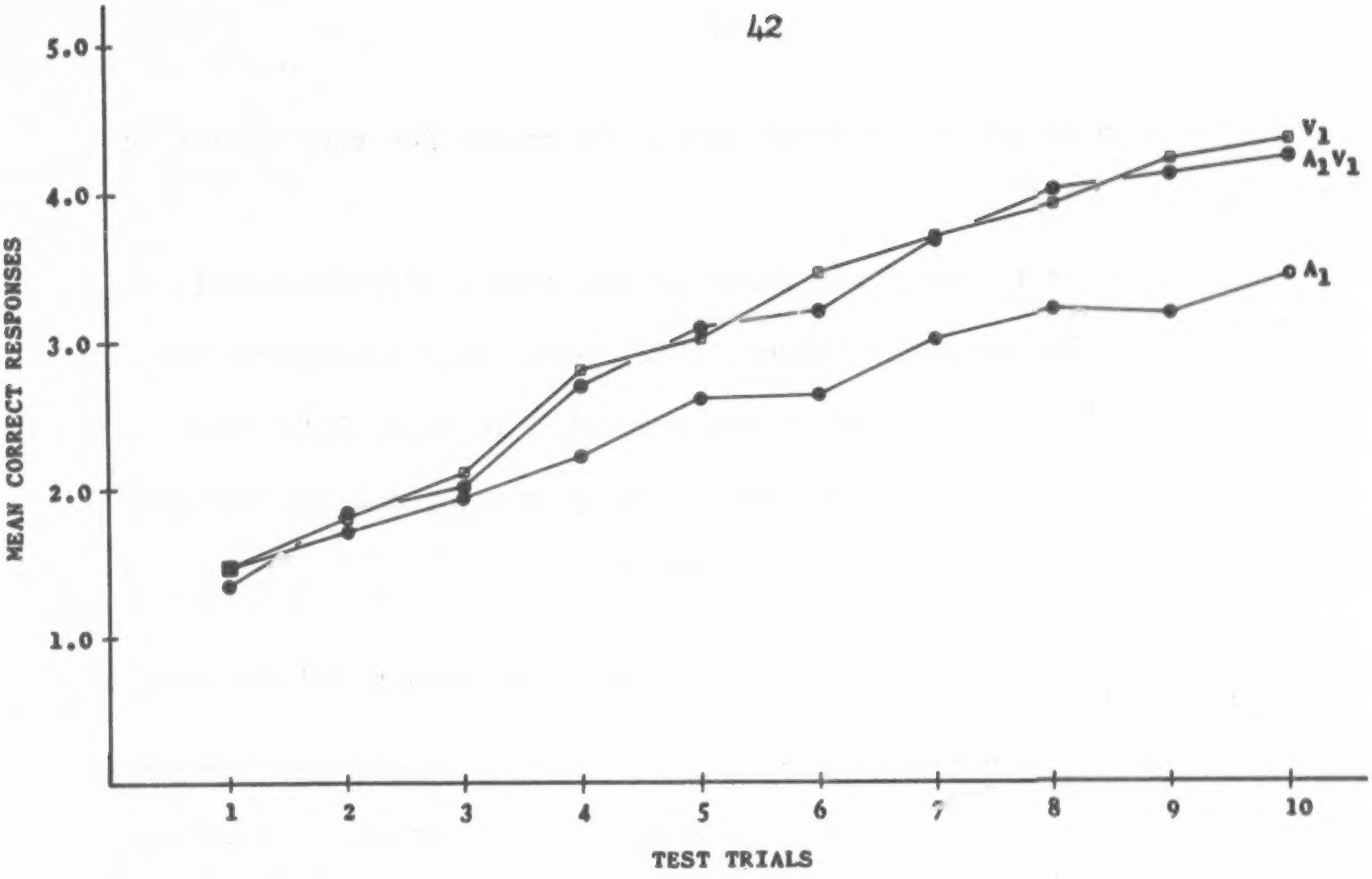


Fig. 2.1 Learning curves for Conditions A_1, V_1, & A_1V_1; grades 3-8 combined.

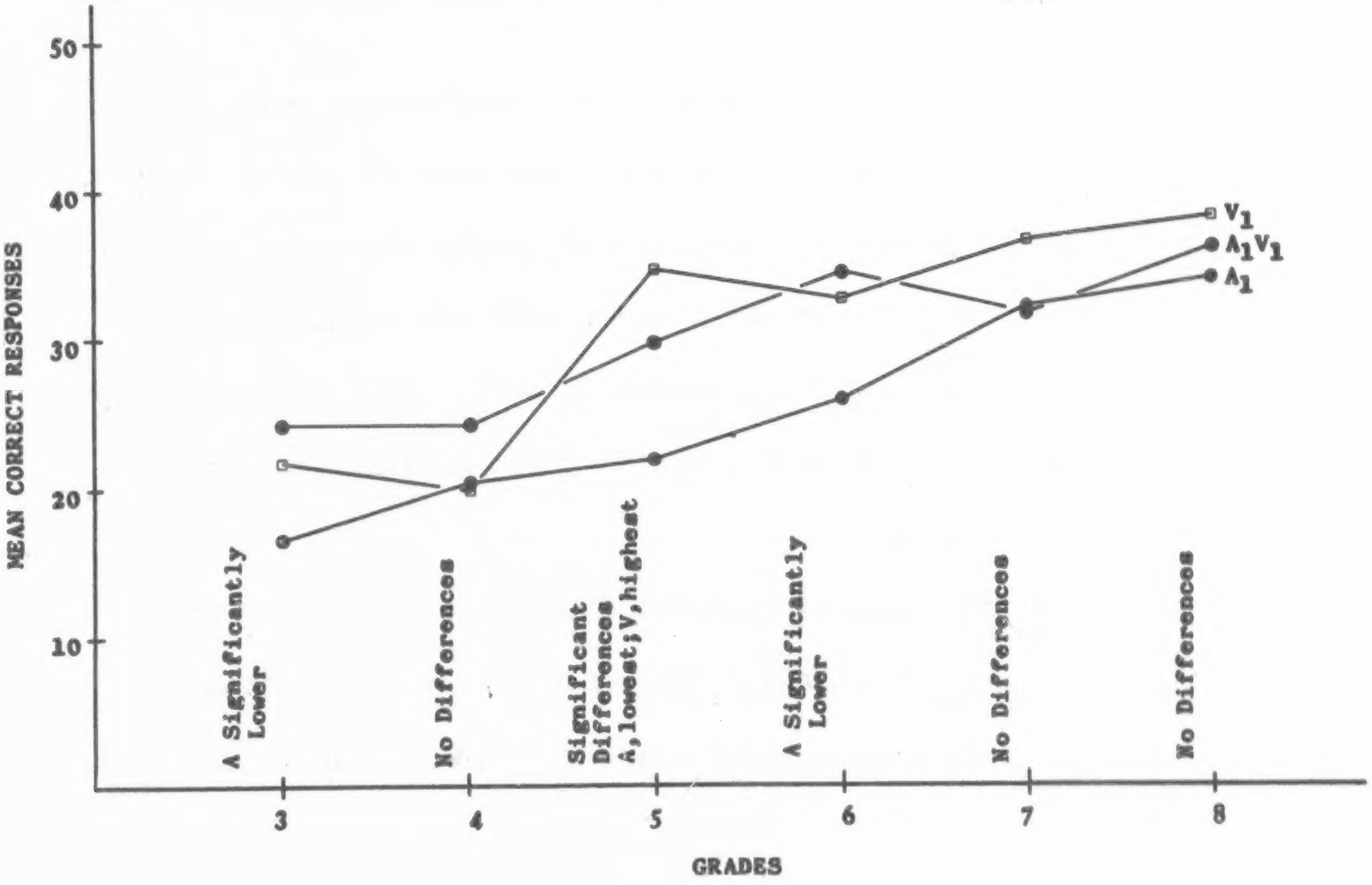


Fig. 2.2 Mean correct responses for Conditions A_1, V_1, & A_1V_1; by grades.

and above. Grade 5 is lower than grade 8 but is not different from grades 6 and 7.

Six simple analyses of variance were made for each grade to test for significant differences between the visual, auditory, and combined presentations within a grade. The results of these analyses are presented in Table 2.5.

Table 2.5. Summary of the six simple analyses of variance of conditions for each grade.

Grade	Source	df	MS	F
3	Modalities	2	891.17	7.54^{**}
	Error	162	118.20	
4	Modalities	2	302.78	2.57
	Error	162	117.61	
5	Modalities	2	2354.13	13.49^{**}
	Error	162	174.56	
6	Modalities	2	1103.04	6.47^{**}
	Error	162	170.38	
7	Modalities	2	375.07	2.19
	Error	162	171.21	
8	Modalities	2	237.29	1.41
	Error	162	168.73	

$^{**}p < .01$

The analyses indicated that there were significant differences among the three modalities in grades 3, 5, and 6. In order to determine which modalities differed from each other, a Newman-Keuls test was carried out on the three grades that showed the significant differences. The results, which are summarized in Table 2.6, indicate that for the

Table 2.6. Results of the Newman-Keuls tests for the three conditions in grades 3, 5, and 6.

Modality	Third Grade	Fifth Grade	Sixth Grade
Auditory	16.54	21.95	26.18
Visual	21.87	29.85	32.82
Combined	24.43	34.93	34.71

third grade the auditory modality is lower than either the visual or combined modalities. There is no significant difference between the visual and combined modalities. In the fifth grade all conditions differ from each other with the auditory condition being the poorest and the combined condition the best. The results of the Newman-Keuls test for the sixth grade indicate that the auditory condition is significantly lower than the visual and combined conditions, which do not differ from each other.

Figure 2.2 (p. 42) summarizes the results of the Newman-Keuls tests for the auditory, visual, and combined presentations within each of the six grades. Inspection of Figure 2.2 reveals a general increase in the mean number of correct responses within each of the three conditions as grade placement increases. These results on nonmeaningful-nonverbal material do not parallel the earlier findings on meaningful-verbal materials. Those results indicated no differences between grades 4, 7, and 10. The data for all three conditions in the present study indicate that the fourth grade performs significantly poorer than the seventh grade.

Figure 2.1 (p. 42) presented the learning curves for the auditory, visual, and combined conditions summing across grades. Figures 2.3-2.8 (pp. 46-48) present the learning curves for each of the three conditions for grades 3-8, respectively. Perhaps the most meaningful portrayal of the data is in Figure 2.9. This figure is the result of combining certain of the curves in Figures 2.3-2.8. The combinations from these figures were based on the results of the follow-up analyses. When these tests indicated no difference among points on the curves, these points were averaged and the resulting values plotted on a single curve. For example, in the seventh and eighth grades no significant differences were found among grades nor among conditions. Thus, it seemed reasonable to average the six points at each trial. This was done and is represented by the "7 and 8; A_1, V_1, A_1V_1" curve in Figure 2.9. Similarly, the remaining four curves in Figure 2.9 show other combinations: (a) 5 and 6; V_1, A_1V_1 (b) 5 and 6; A_1 (c) 3 and 4; V_1, A_1V_1 (d) 3; A_1.

Inspection of Figure 2.9 reveals three distinct levels of learning in this study. The highest level of learning is found for the seventh and eighth grades, all conditions, and for the fifth and sixth grades, visual and combined conditions. Except for the auditory condition for the fifth and sixth grades, the performances for the fifth grade and above are essentially equal on the present material. The second level of performance includes the auditory presentation to grades 5 and 6, all conditions to grade 4, and the visual and combined to grade 3. The lowest level of learning is represented by the curve for the auditory presentation to grade 3.

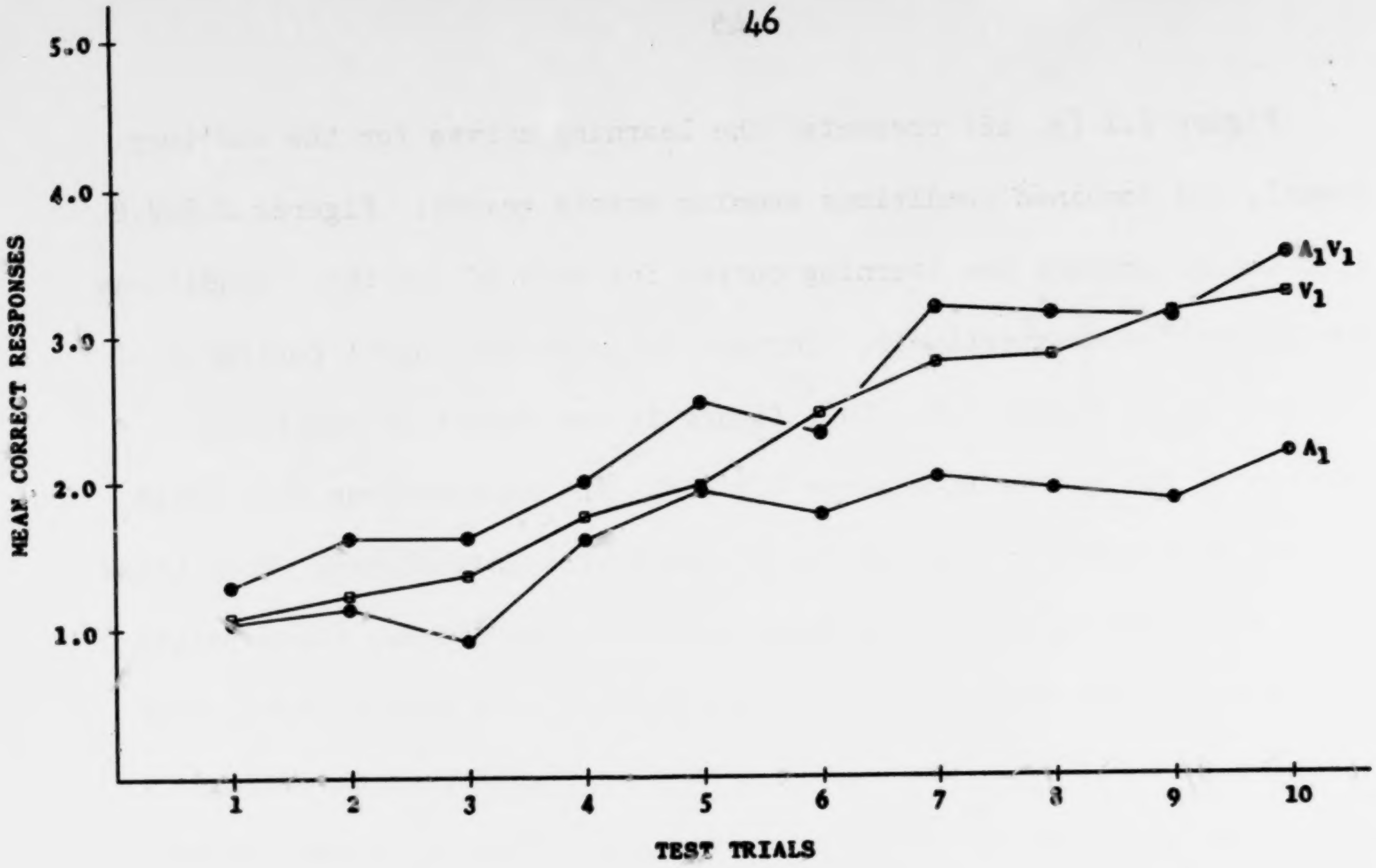


Fig. 2.3 Learning curves for Conditions A_1, V_1, & A_1V_1; grade 3.

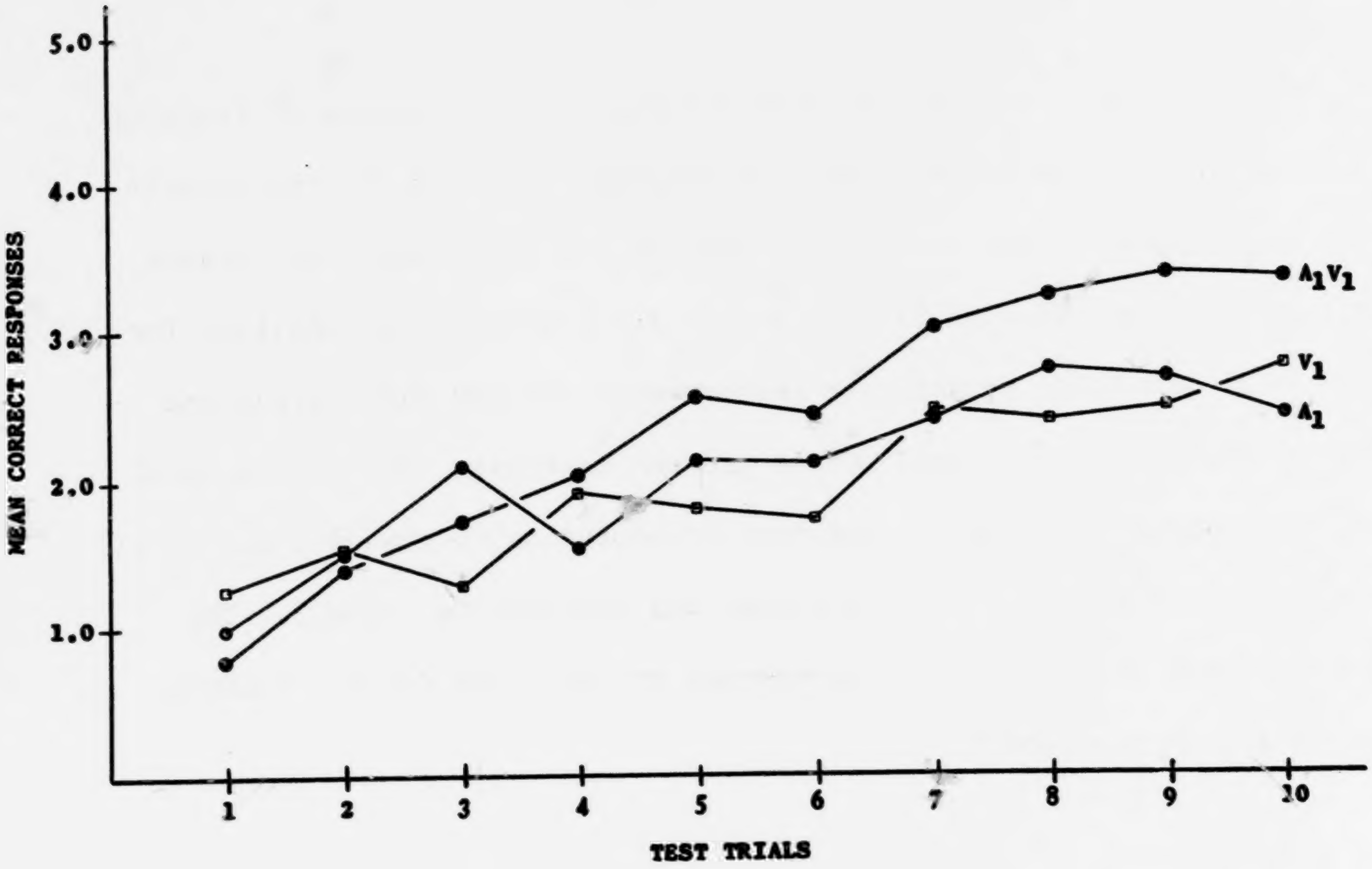


Fig. 2.4 Learning curves for Conditions A_1, V_1, & A_1V_1; grade 4.

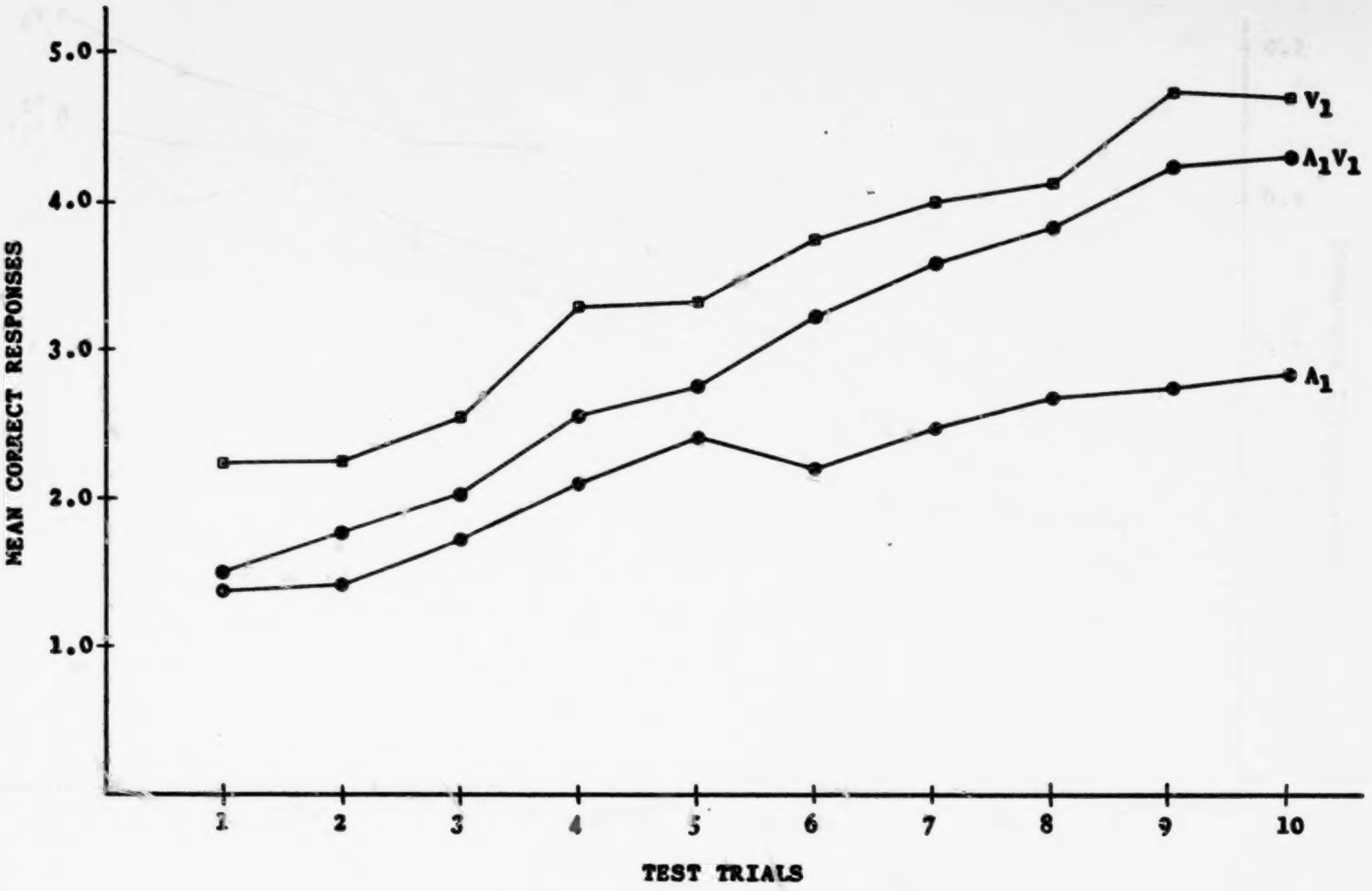


Fig. 2.5 Learning curves for Conditions A_1, V_1, & A_1V_1; grade 5.

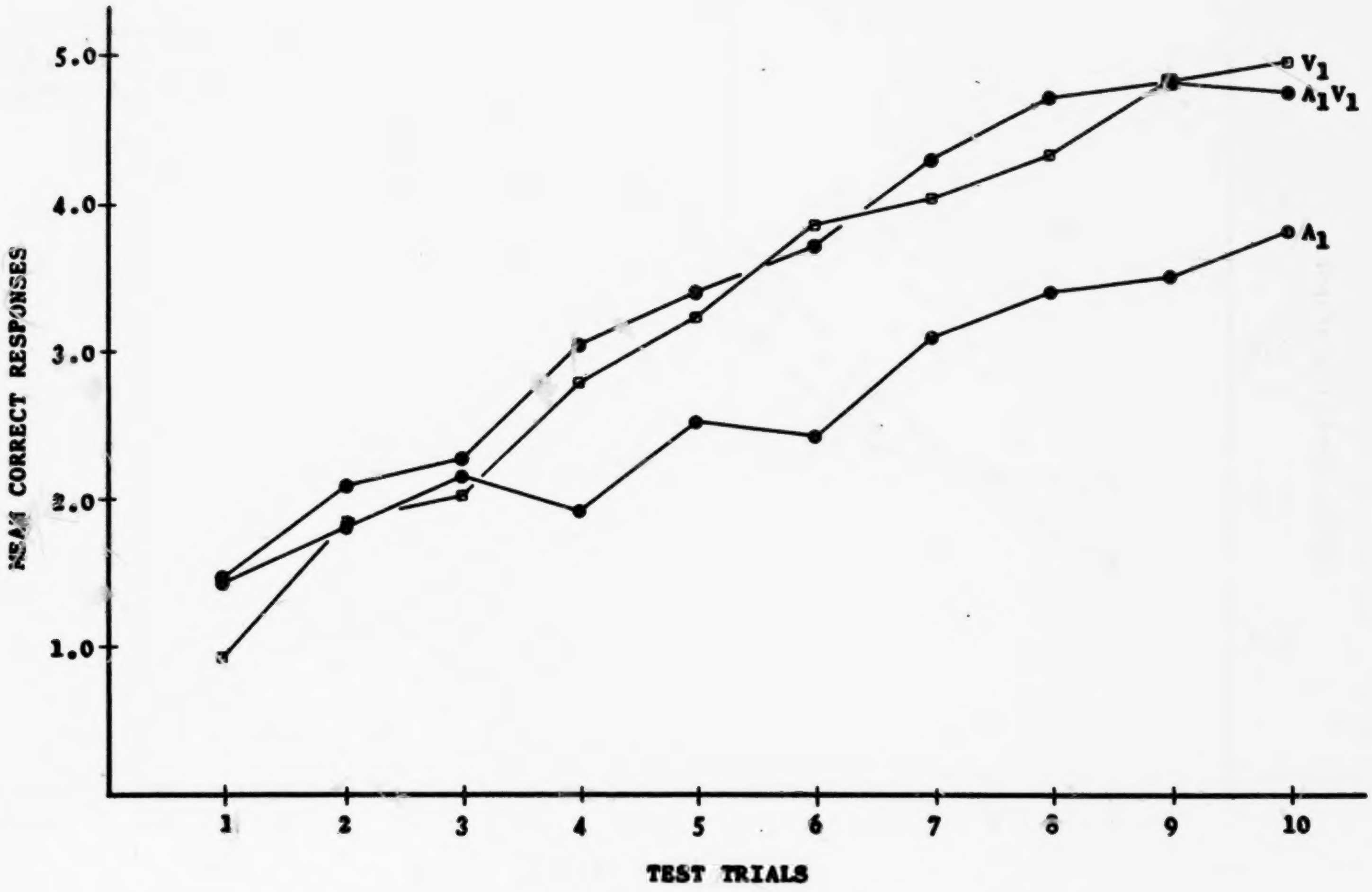


Fig. 2.6 Learning curves for Conditions A_1, V_1, & A_1V_1; grade 6.

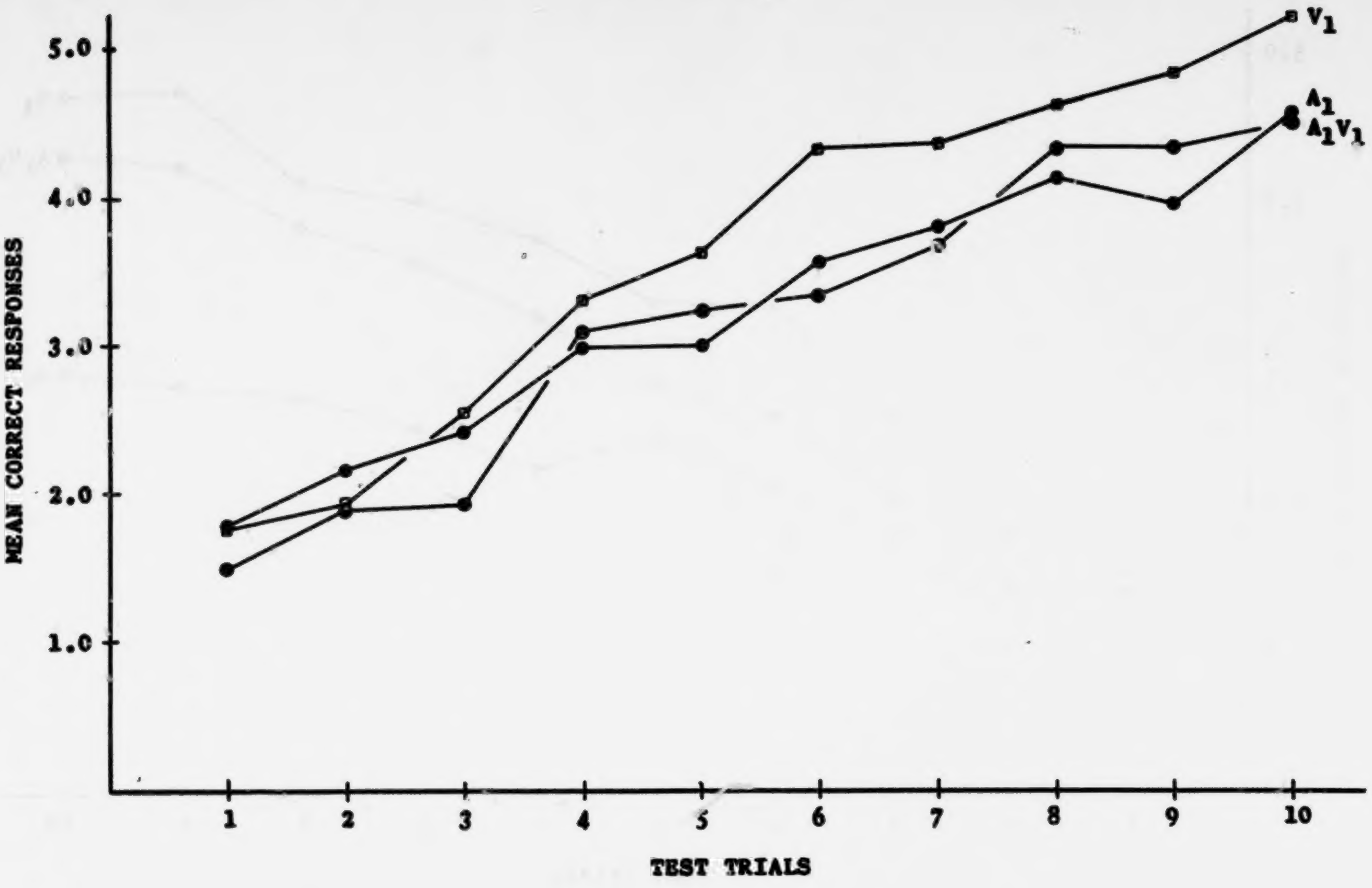


Fig. 2.7 Learning curves for Conditions A_1, V_1, & A_1V_1; grade 7.

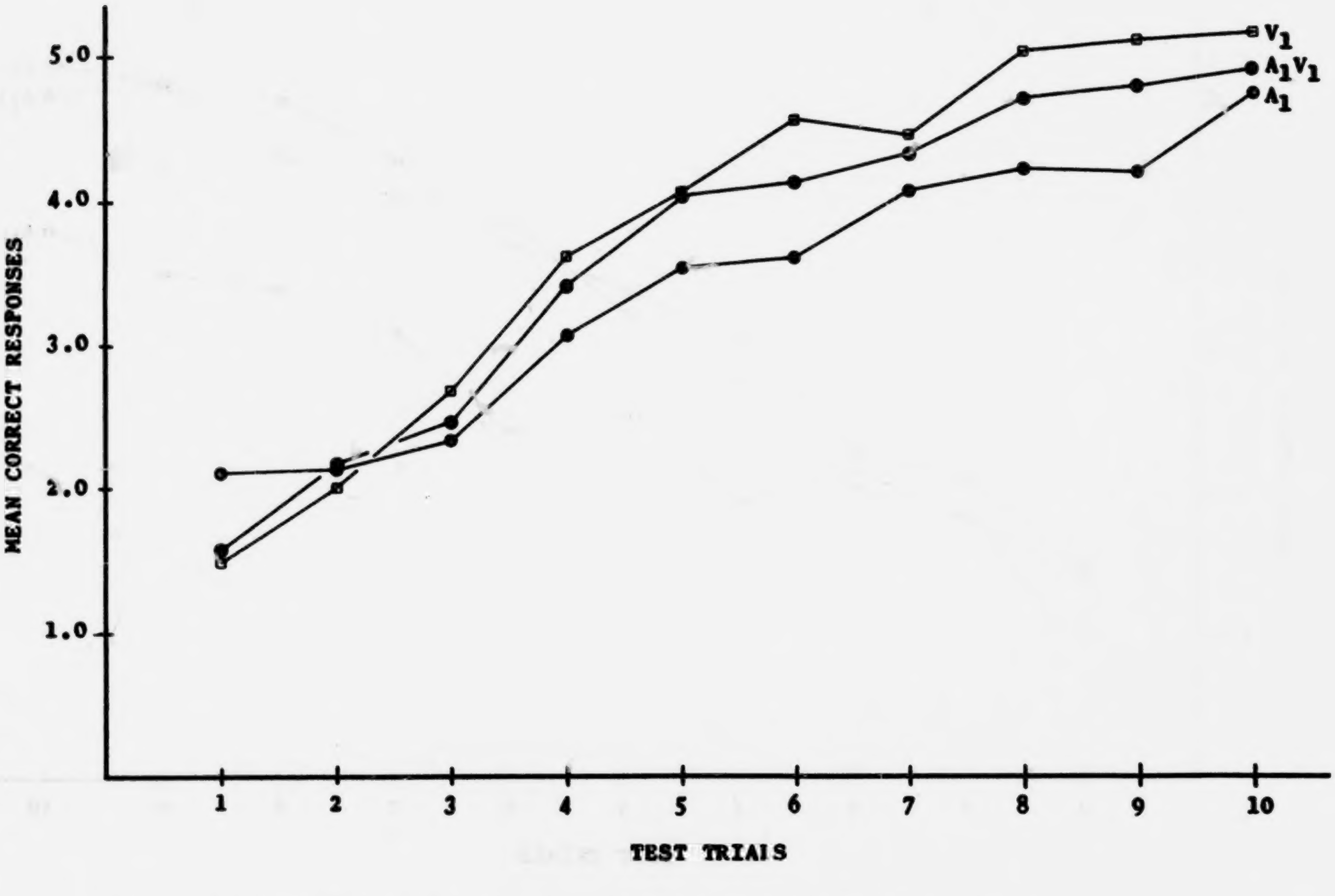
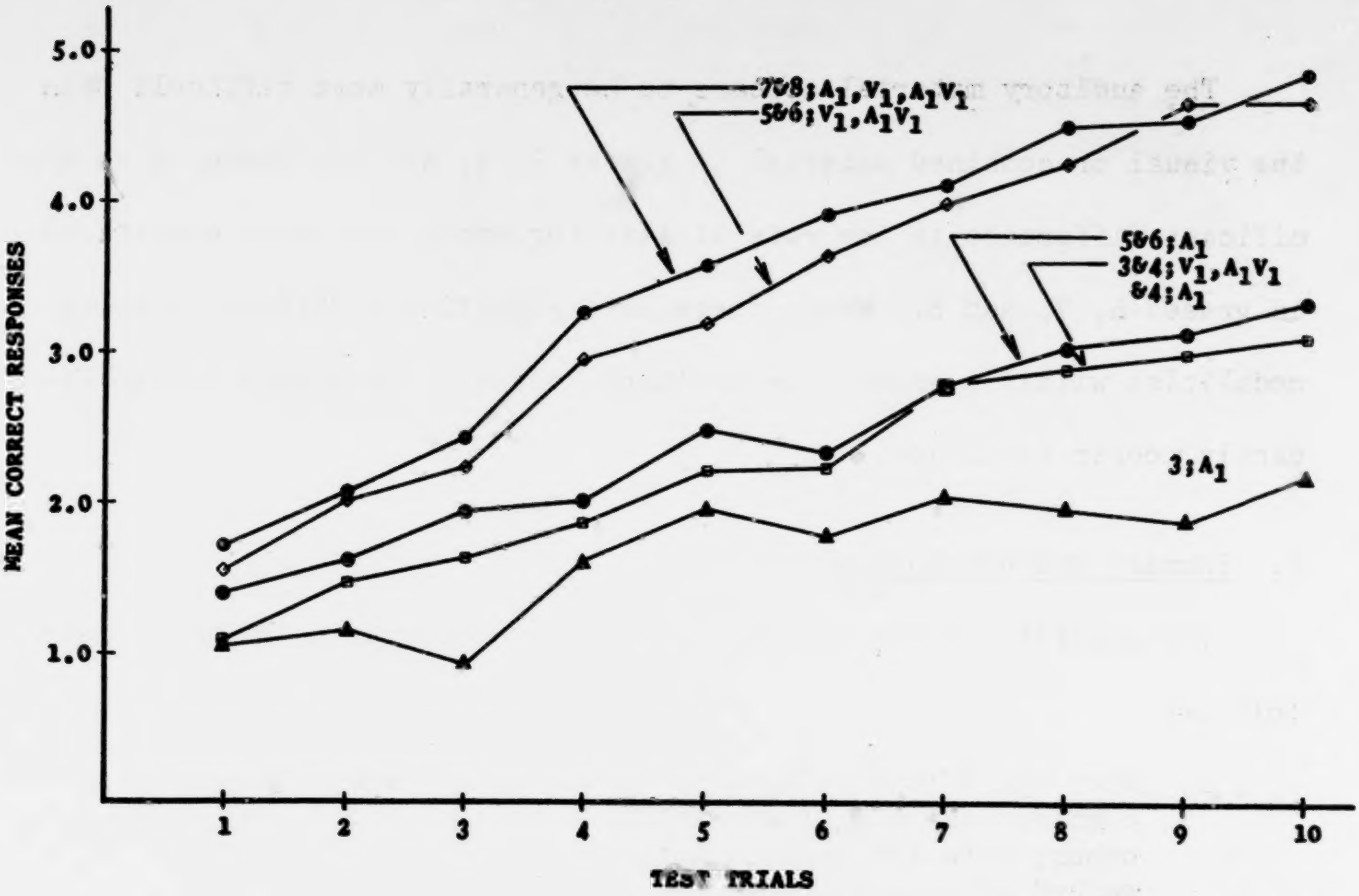


Fig. 2.8 Learning curves for Conditions A_1, V_1, & A_1V_1; grade 8.



F[illegible] 9 Learning curves summarizing equivalent performances.

The auditory material appears to be generally more difficult than the visual or combined material in grades 3, 5, and 6. There is no significant difference in the rate of learning among the three conditions in grades 4, 7, and 8. Where there is a significant difference among modalities within a grade, the auditory condition is always a significantly poorer condition.

E. Summary and Conclusions

The analysis of the results of Experiment II may be summarized as follows:

1. When the effects of grades are pooled, the visual and combined methods of presentation do not differ from each other; both are significantly better than the auditory method of presentation, but the auditory material was undoubtedly more difficult.
2. When sensory methods of presentation are considered separately, there is a general improvement in performance from grades 3 through 8 for each method of presentation. However, the significances from grade to grade differ from one sensory method of presentation to another.
3. Although the trend described in the first two conclusions is supported by the statistical analyses, the significant interaction between modalities and grades attests to certain inconsistencies in these trends.

There is no indication of any acceleration operating with the combined condition. In Figure 2.1 where the data for the three conditions are averaged across grades, the combined and visual curves are practically identical as opposed to the auditory curve. It is concluded that for the nonmeaningful-nonverbal materials of the type used in this study the performance in the visual and combined conditions is either equal to or better than the performance in the auditory condition.

The results of Experiment II extend the inferences drawn from some of the other experiments and tend to limit some of the previous conclusions. It has been observed repeatedly with meaningful-verbal material that the combined method of presentation is not superior to the better of the other two conditions, A or V. It is now assumed that this general conclusion also applies to the type of nonmeaningful-nonverbal material utilized here. The learning curves for grade 4 (shown in Figure 2.4) suggest a possible exception to this conclusion in that the curve for the combined presentation is superior to the other two conditions. However, the total number of correct responses were not significantly different among the three conditions and the preponderance of the evidence continues to favor a hypothesis of no difference between the combined presentation and the better of the other two methods.

Conclusions drawn concerning differences between the auditory and visual methods of presentation must be limited to the specific materials used here and not generalized loosely to modalities. The A_1 and V_1 materials were generated separately and were not standardized for equivalence of difficulty in any grade. The differences between A_1 and V_1 must be assumed to include the possible confounding factor of list differences.

An earlier conclusion (Gaeth, 1960) that there was a plateau in the learning of paired-associates material at the fourth grade without marked improvement in performance for the higher grades no longer appears to be valid. An inspection of Figure 2.2 reveals a trend of general improvement and increase in performance from grade 3 through grade 8. Since the meaningfulness of the material is assumed to be constant across grades, the improvement in performance can be attributed to a "learning to learn" phenomenon (Harlow, 1949).

One of the assumptions underlying the design of Experiment II was that the combined method of presentation, providing in this instance not a duplication of information, as in spoken "dog" and printed "dog", but additional information, might prove superior to the auditory or visual methods of presentation. To explain: By presenting different stimuli simultaneously in the combined condition, distinct characteristics of one of the stimuli (auditory or visual) may facilitate the differentiation of the stimulus item or the association to the response. It was also assumed that the learning of nonverbal and nonmeaningful material which, of necessity, was also completely unfamiliar might in some way be analogous to the task confronting the child in his first contact with new material. Under these circumstances perhaps the combined method of presentation would be superior. However, the results did not bear out this assumption.

Experiment III

Learning in Grades 2-12; Fifteen Conditions

ABSTRACT. Paired-associate learning of single-letter responses was studied in large numbers of subjects from seven grades. Stimuli were selected in an attempt to encompass a large range of the meaningfulness dimension and were presented auditorily and visually either unimodally or bimodally. Performance was related to grade level, modality of presentation, and level of meaningfulness and verbalness. Results indicated that less of the variance in the learning scores could be attributed to modality of presentation or to verbalness than to the meaningfulness variable.

A. Introduction

In our earlier research, reviewed briefly in Related Research, no significant differences were found when paired-associate learning material was presented bimodally and the results compared to visual or auditory presentations. Likewise, no significant differences were found across grades 4 through 10 even though there may have been a trend toward better performance in the higher grades. It was assumed that fully meaningful material, common nouns, did not provide an adequate test of the expected superiority of a bimodal presentation over a unimodal presentation. To explain: Once a concept has been fully established the ability to utilize that concept in a simple task is independent of the sensory modalities which trigger it. For instance, the printed word "dog", the spoken word "dog", a line drawing of a dog, and even the sound of a dog barking would each provide equivalent stimulation as far as the particular tasks utilized were concerned. If this assumption is correct, then one would not expect better performance in a bimodal presentation. It would then follow that the study of performances utilizing bimodal presentations versus unimodal presentations of fully meaningful material may not be analogous to the process that goes on when a child is developing a new concept. A main difference between the three-letter combination "daq" and "dog" is that of meaningfulness. The fact that bimodal presentations were not superior for highly meaningful material does not prove that they would not be superior for material which is low in meaning.

The present experiment was planned to extend the scope of single and bimodal presentations in the auditory and visual modalities to include nonmeaningful and nonverbal materials in a variety of straight and mixed presentations. Because of the complexity of the design, the test materials are reviewed again and the methods of presentation are spelled out in some detail.

Three types of materials were utilized:

1. Nonmeaningful-nonverbal material. A series of visual symbols were prepared that generated few associations and did not lend themselves readily to verbal labels. They are referred to as V_1. Unfamiliar noises were recorded and are designated as A_1.
2. Nonmeaningful-verbal material. Three-letter nonsense syllables, with low associative values, were selected from standardized lists. Since these items were readily pronounceable, they were considered verbal but not meaningful. When presented visually, they are referred to as V_2, and when presented auditorily, they are referred to as A_2.
3. Meaningful-verbal material. Common three-letter nouns were utilized. These are designated as V_3 or A_3.

Once the visual material had been put on slides and the auditory material had been recorded, a total of fifteen conditions were available for presentation. The fifteen conditions can be understood by reference to Table 3.1. The unimodal conditions are indicated by the marginals of the matrix, and the combined conditions defined by the cells in the matrix.

Table 3.1. Symbolic representation of the fifteen conditions.

	A_1	A_2	A_3
V_1	A_1V_1	A_2V_1	A_3V_1
V_2	A_1V_2	A_2V_2	A_3V_2
V_3	A_1V_3	A_2V_3	A_3V_3

There were six unimodal, three auditory and three visual, conditions. The capital letter represents the sensory channel and the Arabic numeral the level of meaningfulness and/or verbalness. The three visual conditions were presented under identical circumstances; i,e., all factors including the response items were the same except for the stimulus material. The same was true for the three auditory conditions. The nine conditions inside the lines on the table were all audio-visual conditions. All combinations of A and V were utilized. The basic combined conditions are shown on the diagonal from upper left to lower right. In our previous studies, the combined meaningful condition, A_3V_3, was not superior to A_3 or V_3. The Condition A_2V_2, in which the nonsense syllables were both seen and heard simultaneously, was designed to test for the superiority of this condition over either the auditory or the visual presentation. It is possible that merely seeing a nonsense syllable and never hearing it pronounced would create uncertainty in connection with this stimulus item and produce lower learning scores than would be achieved when both the spelling and the pronunciation were provided. Similarly, there might be doubt associated with the spelling of the stimulus when it was only pronounced. In Condition A_1V_1, one might assume more associative aspects in the combined stimulus than in either the auditory or visual alone. If the number of available aspects per se were to facilitate the learning and usefulness of the stimulus, then A_1V_1 should be superior to A_1 or V_1 presented alone.

The remaining six conditions within the table represent an intermixing of the levels of meaningfulness and verbalness. In the A_1 column, A_1V_2 represents a condition in which the unfamiliar noises are presented simultaneously with the printed nonsense syllables. The difference between A_1 and A_1V_2 was that printed labels were provided with the noises in the latter condition. In A_1V_3 the noises were presented with highly familiar nouns. Similarly, in the V_1 row, for A_2V_1, the visual symbols were presented with spoken nonsense syllables, thereby providing the subject with a verbal label to utilize in learning the unfamiliar symbols.

B. Background and Related Research

Various investigators have found that meaningfulness, defined in several different ways, is related in a systematic fashion to rate of verbal learning. Glaze (1928) attempted to scale nonsense syllables. Hull (1933) and Krueger (1934) made similar attempts and, in terms of sample size and methodological procedures, could probably be termed more successful in their attempts. However, despite the limitations, the norms of Glaze have been used most frequently. Davis (1930) and McGeoch (1930) have shown a positive, although somewhat irregular, relationship between Glaze's association values and learning of serial lists. Using Noble's scale values, Noble (1952) and Dowling and Braun (1957) found a regular positive relationship between meaningfulness and learning of serial lists. With paired-associate material, similar, although much less regular, positive relationships have been obtained. Kimble and Dufort (1955) sampled different points along Noble's scale of dissyllables. Pairs of items had the same scale value, but the value was manipulated within a list. Noble and McNeely (1957) used much the same procedure except that the value was constant within a list but was varied across lists. In both of these studies, fewer errors or more rapid correct anticipations were obtained at high as compared to low scale value.

Several studies have manipulated meaningfulness within stimulus-response pairs. Cason (1933) used lists with four combinations of S-R meaningfulness: H-H, H-L, L-H, and L-L. The high M units were familiar three-letter words, while the low M were nonsense syllables. The complete presentation method was used, and the lists were given either visually or auditorily. The test was immediate free recall. Modality of presentation had little effect, and recall for H-L and L-H was approximately equal. Sheffield (1946) used much the same materials, but time factors were much more precisely controlled through the use of a memory drum. Contrary to Cason, Sheffield found that H-L pairs were only slightly better than L-L pairs, and L-H pairs were only slightly inferior to H-H pairs. Thus, Sheffield's data indicate that difference in the meaningfulness of the stimulus produces relatively minor changes in rate of learning as compared with corresponding differences in the meaningfulness of the response.

Two studies of considerable interest were reported by Cieutat, Stockwell, and Noble (1958). They used Noble's dissyllables with widely different scale values for four combinations of high and low pairs as discussed above. While (as had been found in all previous studies) acquisition of H-H lists was significantly superior to L-L lists; the L-H and H-L lists did not differ significantly. They report that the variance attributable to response variation is approximately 2.6 times that attributable to stimulus variation.

L'Abate (1959) used Glaze syllables to form the same combinations of stimulus and response meaningfulness. Results again indicated that stimulus M was of small consequence for learning. Comparable results have been reported by Weiss (1958) and also by Morikawa (1959) using materials scaled for Japanese subjects.

The findings cited above indicate that variation in stimulus M has less effect on learning rate than comparable variation in response M. The fact that variation in stimulus meaningfulness produces little effect is important in relation to the present research. Since the manipulation of meaningfulness occurs in the stimulus term, such findings would tend to minimize the likelihood of the proposed manipulations of meaningfulness having significant effects. On the other hand, the response component has been held constant while various stimulus manipulations were carried out. This is in contrast to most of the previous studies which varied both the stimulus and response components, thus making it difficult to measure and interpret the effects of variation in meaningfulness (and verbalness) of the stimulus component.

Several additional factors also need to be considered in regard to the exploration of meaningfulness in the stimulus term. The first is that such relationships have been investigated almost exclusively for the visual modality. It would seem fruitful to pursue such relationships utilizing auditory and combined audio-visual presentations. Secondly, subjects in the previous studies were all of college age. The effects of meaningfulness need to be investigated at various educational and age levels. Thirdly, and probably most important, meaningfulness has previously been investigated within various verbal materials. The present research proposes to go beyond the verbal dimension by using nonverbal visual and auditory stimuli, hoping thereby, to extend the range of manipulation of the meaningfulness dimension.

Data relating to these problems are of two kinds and are presented under two headings. The first set of data, presented under Part I, considers modalities, meaningfulness, and verbalness somewhat indirectly through comparisons of learning scores for single visual or auditory modalities, and through comparisons of various bimodal presentations of stimuli. Part II reports an attempt to study modalities more directly. Stimuli were presented initially in the nine bimodal combinations for ten trials and then an additional eleventh trial was given in either single modality for independent groups. Learning scores on the eleventh trial relative to the tenth trial scores give a somewhat more direct indication of modality preference.

C. Results: Part I

A large number of subjects, over 4000, were tested on Conditions A_1, A_2, A_3, V_1, V_2, V_3, and all combinations of A-V. For all the conditions indicated, data were collected from subjects in grades 4, 5, 6, and 10. In addition, for certain conditions and comparisons of conditions, data were also collected on subjects from grades 2, 3, and 12. Responses were single letters that were to be recognized and circled for subjects in grades 2 and 3 and were to be recalled and written for subjects in higher grades. Standard paired-associate instructions were given. The procedures for the presentation of the stimuli and responses have been discussed previously.

The results for Part I are presented in the following order: (1) Learning by grade level, (2) Effect of meaningfulness and verbalness, simple conditions, (3) Bimodal versus unimodal presentations, (4) Combined and mixed conditions, (5) Mixed conditions, A_1 constant, (6) Mixed conditions, A_2 constant, (7) Mixed conditions, A_3 constant, (8) Mixed conditions, V_1 constant, (9) Mixed conditions, V_2 constant, (10) Mixed conditions, V_3 constant, and (11) Effect of meaningfulness, bimodal conditions.

1. Learning by grades. The data from the present experiment lend themselves to a wide variety of comparisons in which one or another aspect of the material or methods of presentation is considered somewhat independently. In all of these analyses, the effects of grades are also considered. In every such analysis, the variance attributable to grades is highly significant. However, as with Experiment II, the mean differences among grades varies from condition to condition. The details of

these differences are available in the tables summarizing the analyses in the various sections which follow. For simplicity of presentation, the data by grades are given initially.

Table 3.2 presents the mean correct responses for the fifteen conditions by grades 2, 3, 4, 5, 6, 10, and 12. The total number of

Table 3.2. Mean correct responses by grades and conditions.

Conditions				Grades			
	2	3	4	5	6	10	12
A_1			20.4	22.0	26.2	39.4	41.1
A_2			16.3	24.2	24.1	39.3	37.5
A_3			33.8	36.8	33.6	53.3	56.5
V_1			19.8	34.9	32.8	43.4	47.0
V_2			23.5	25.6	30.3	41.2	44.0
V_3			35.0	38.0	43.9	48.8	54.0
A_1V_1	20.9	22.4	26.9	30.9	32.5	43.0	40.1
A_1V_2	17.0	19.3	23.6	23.9	27.8	42.7	42.1
A_1V_3	23.6	25.5	28.6	35.0	43.9	48.4	50.4
A_2V_1	15.3	18.5	26.6	25.6	28.0	43.7	39.6
A_2V_2	15.2	20.2	21.4	23.6	30.3	38.9	
A_2V_3	16.6	16.5	23.0	32.9	33.2	41.4	
A_3V_1	26.0	34.9	39.6	40.3	40.3	50.7	52.2
A_3V_2	24.1	29.7	32.6	29.7	37.4	45.7	
A_3V_3	38.1	28.9	33.3	41.0	49.2	55.2	
$\bar{X}$	21.9	23.6	27.0	31.0	34.2	45.4	46.4

subjects represented by this table is 4,128. The summarizing means at the bottom of Table 3.2 and in Figure 3.1 (p. 63) show a clear progression in the mean learning scores across grades with a plateau appearing at about the tenth grade.[1] In the main, from grades 2 through 10 there is an increment of about three units per grade. On the basis of the statistical analyses done in connection with the subsections of the experiment, it appears reasonable to assume that two adjacent grades do not differ significantly from each other on these particular data, but all non-adjacent grades would be significantly different.

The data rather clearly contradict the inference drawn in the previous project that learning scores probably plateau at about the fourth or fifth grade.

2. Effect of meaningfulness and verbalness, simple conditions. Table 3.3 gives the means, standard deviations, and sample sizes for the three auditory conditions, and Figure 3.2 (p. 63) presents the same data graphically. Inspection of the figure indicates progressive improvement in performance across grades. It also illustrates the superiority of Condition A_3, meaningful-verbal material, at all grade levels. There is very little difference in the curves representing Conditions A_1 and A_2. Even though the relative difficulty of the two lists was not determined, there is no clear evidence that the pronounceability of A_2 makes it superior to the nonverbal noises. If anything, the performance under this condition is poorer.

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1. Learning curves for each of the fifteen conditions are given in Appendix A for all grades.

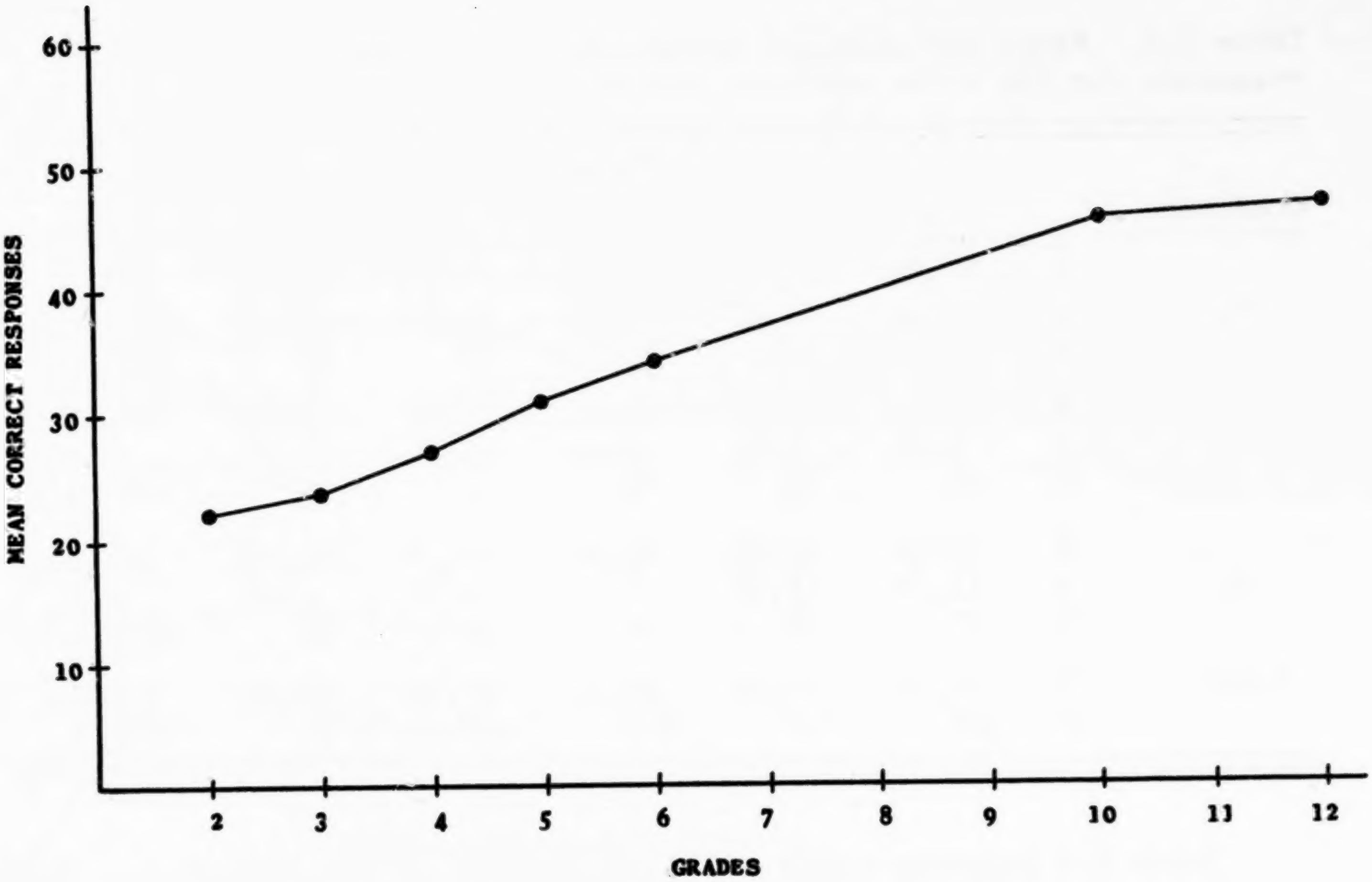


Fig. 3.1 Mean correct responses for all conditions, by grades.

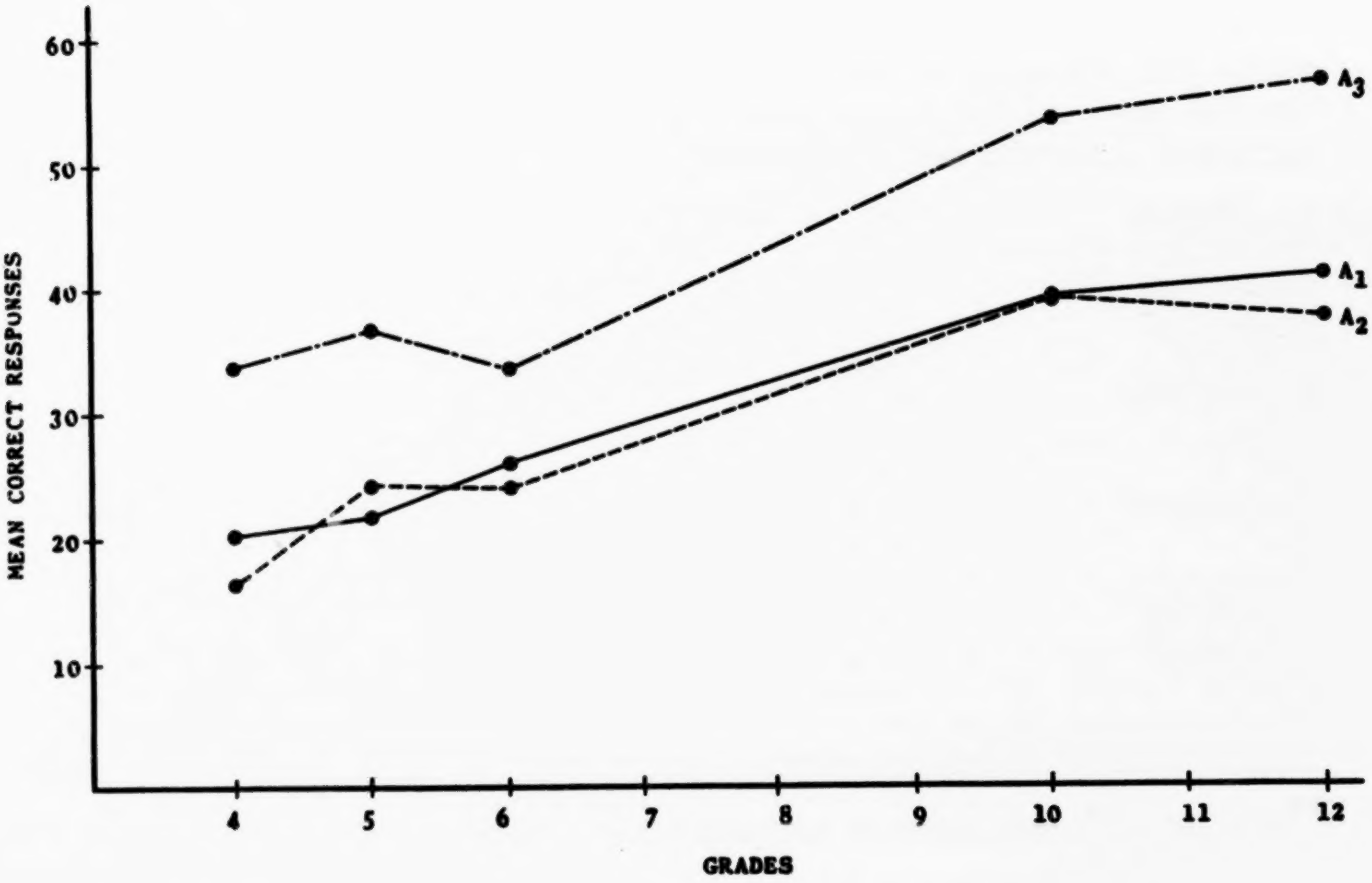


Fig. 3.2 Mean correct responses for Conditions A_1, A_2, & A_3; by grades.

Table 3.3. Means and standard deviations of the number of correct responses for the three auditory conditions in five grades.

Condition		Grade 4	5	6	10	12	Total
A_1	$\bar{X}$	20.38	21.95	26.18	39.39	41.06	28.75
	s	10.44	11.47	13.05	11.47	12.10	
	N	55	55	55	56	31	252
A_2	$\bar{X}$	16.27	24.16	24.07	39.27	37.54	24.70
	s	9.91	12.91	12.45	14.94	14.06	
	N	55	55	55	15	24	204
A_3	$\bar{X}$	33.75	36.85	33.64	53.27	56.54	40.81
	s	14.35	13.92	15.40	8.31	6.56	
	N	55	55	55	45	28	238
Total	$\bar{X}$	23.47	27.65	27.96	44.76	45.27	31.70
	N	165	165	165	116	83	694

Table 3.4 presents a summary of the results of the analysis of variance and of the Scheffe procedure carried out on the auditory conditions across these grades. The variances for both grades and conditions are

Table 3.4. Summary of the analysis of variance and of the Scheffe tests for the three auditory conditions and five grades.

Source	df		MS		F
Conditions (C)	2		12609.25		79.52**
Grades (G)	4		12090.15		76.25**
C x G	6		274.51		1.73
Within Cell	649		158.56		
$\bar{X}$	24.70		28.75		40.81
Conditions#	A_2		A_1		A_3
$\bar{X}$	23.47	27.65	27.96	44.76	45.27
Grades#	4	5	6	10	12

**p < .01. #Lines connect nonsignificant differences at p = .01.

highly significant. The Scheffe analysis indicates that grade 4 is significantly lowest and that grades 5 and 6 do not differ from each other but are significantly lower than 10 and 12.

The Scheffe analysis of the conditions confirms the superiority of the meaningful-verbal condition; however, it also reveals Condition A_1 as superior to Condition A_2. Re-inspection of Table 3.3 suggests that this finding must be interpreted with caution. The row mean, 24.70, for A_2 is reduced because there were only fifteen subjects in grade 10 for this condition. If the mean for this grade and condition were to remain at 39.27 and N were to be increased to 55, or even if the mean were to drop to 35.00 with the increase in N, the row means would be 27.09 or 26.13 instead of 24.70.

The most reasonable interpretation of the data is that the meaningful-verbal auditory condition is clearly superior to the nonmeaningful-nonverbal and the nonmeaningful-verbal conditions, but that the latter two do not differ significantly from each other.

Table 3.5 and Figure 3.3 (p. 67) present the same basic data for the three visual conditions. Again, the meaningful-verbal condition is superior across all grades. The nonmeaningful-nonverbal condition appears slightly superior to the nonmeaningful-verbal condition for all grades except grade 4.

Table 3.6 presents the summary of the analysis of variance for the three visual conditions and five grades. The results indicate that both conditions and grades were significant; however, since the interaction was also significant, the main effects could not be interpreted readily. From an inspection of Figure 3.2, it appeared that the fifth grade was

Table 3.5. Means and standard deviations of the number of correct responses for the three visual conditions in five grades.

Condition		Grade 4	5	6	10	12	Total
V_1	$\bar{X}$	19.84	34.93	32.82	43.39	47.04	34.50
	s	9.66	14.33	13.55	12.28	9.05	
	N	55	55	55	59	28	252
V_2	$\bar{X}$	23.53	25.56	30.29	41.22	44.04	31.87
	s	11.81	12.44	13.07	11.09	12.50	
	N	55	55	55	59	28	252
V_3	$\bar{X}$	34.98	38.00	43.91	48.80	53.96	42.48
	s	13.35	14.33	9.70	11.94	7.07	
	N	55	55	55	50	23	238
Total	$\bar{X}$	26.12	32.83	35.67	44.24	49.99	36.17
	N	165	165	165	168	79	742

the primary source of this interaction. An analysis, excluding the fifth grade, bore out this assumption; the interaction was no longer significant. Since this analysis was post hoc, there appeared to be little reason for deviating from the original analysis.

Table 3.6. Summary of analysis of variance for the three visual conditions and five grades.

Source	df	MS	F
Conditions (C)	2	7428.63	50.27^{**}
Grades (G)	4	10863.58	73.51^{**}
C x G	8	375.93	2.54^{**}
Within Cell	727		

$^{**}p < .01$

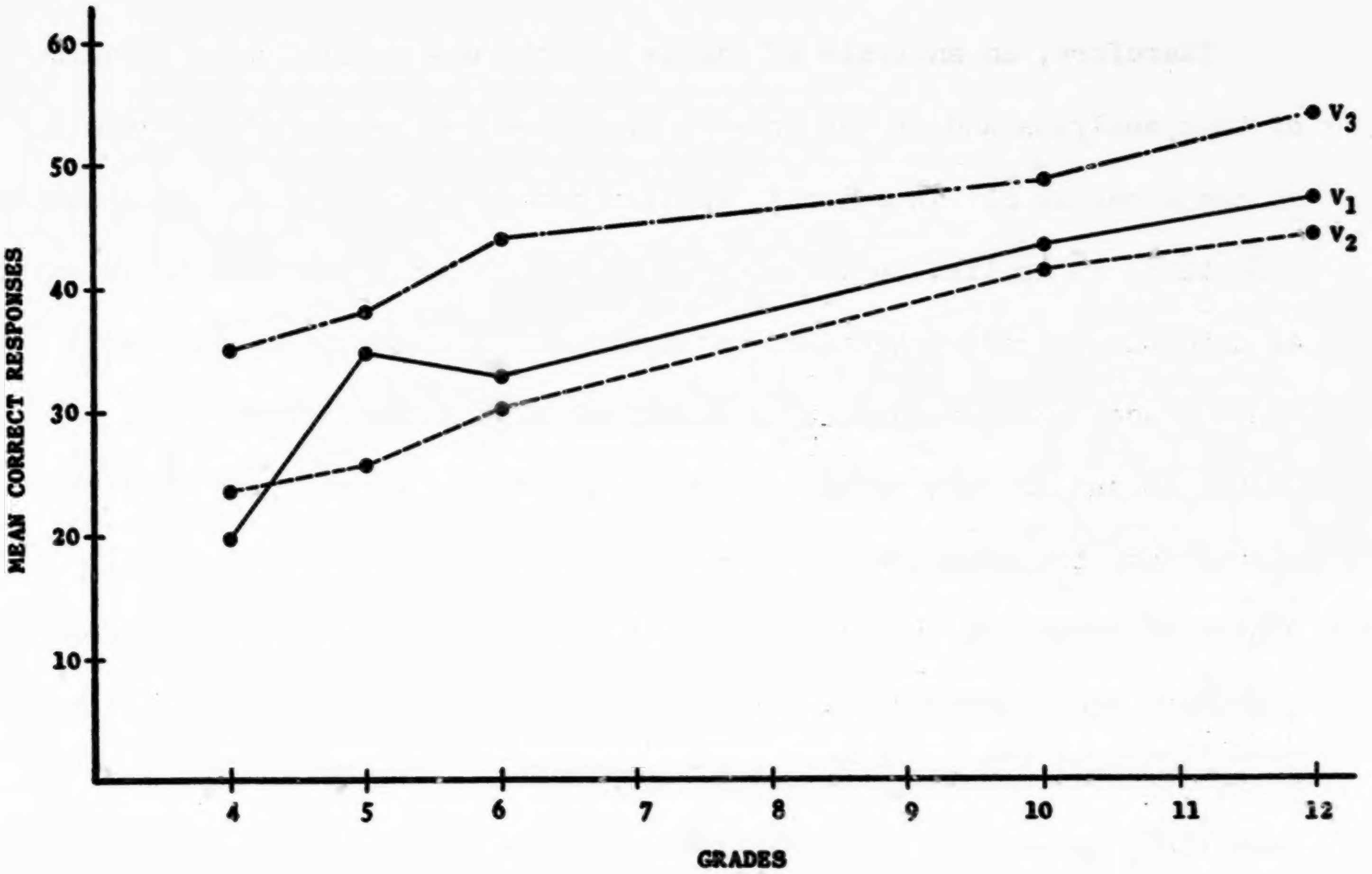


Fig. 3.3 Mean correct responses for Conditions V_1, V_2, & V_3; by grades.

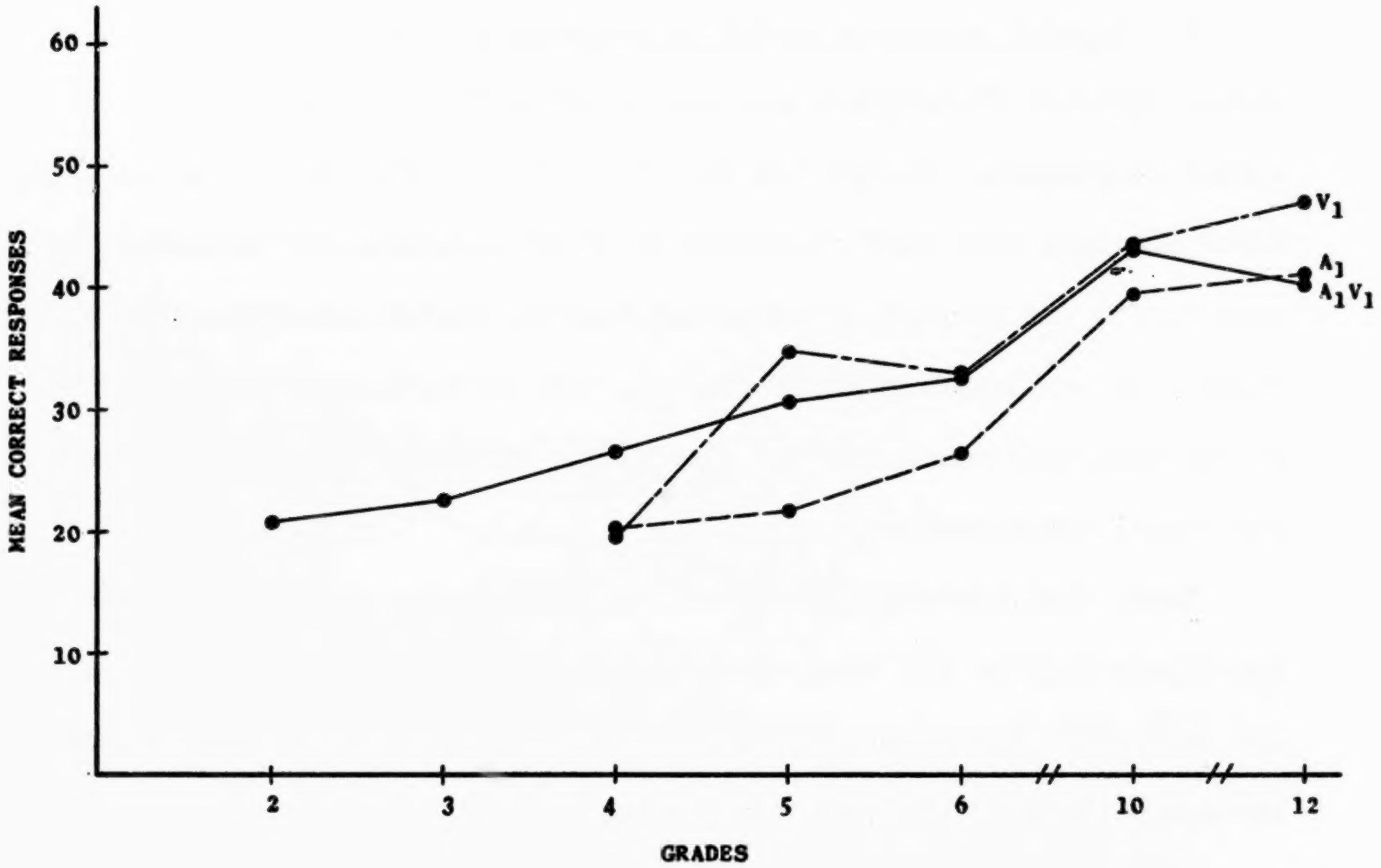


Fig. 3.4 Mean correct responses for Conditions A_1, V_1, & A_1V_1; by grades.

Therefore, an analysis of simple effects was carried out. Results of this analysis and of the Scheffe procedure are presented in Table B.1 in the Appendix B. In general, similar conclusions apply to the visual conditions as applied to the auditory ones, although the results are not as dramatic. Grade 4 tends to be significantly poorer than all the other grades with nonmeaningful-nonverbal material and poorer than grades 10 and 12 when verbal materials are used. As with the auditory conditions, the verbalness of the nonsense syllables does not result in better performances than is found with symbols since the nonmeaningful-nonverbal and nonmeaningful-verbal conditions do not differ significantly in any grade. However, the clear superiority of the meaningful-verbal condition, noted with the auditory conditions, is not found here. The meaningful-verbal condition, while superior to the nonmeaningful-verbal condition in all grades, is significantly so only in grades 5 and 6.

3. Bimodal versus unimodal presentations. Table 3.7 presents the means, standard deviations, and sample sizes for the nonmeaningful-nonverbal conditions. Figure 3.4 (p. 67) presents these values graphically. Since the data were used primarily in other analyses, the presentation here is for the purpose of comparing bimodal versus unimodal presentations. As concluded in Experiment II, the auditory material appears to be the most difficult, and the bimodal presentations are not superior to the visual presentations.

Table 3.8 presents the scores for the nonmeaningful-verbal material and Figure 3.5 (p. 70) shows the relationship graphically. Again there are only small differences between the visual and combined conditions, and again the auditory condition is the poorest.

Table 3.7. Means and standard deviations of the number of correct responses for the three nonmeaningful-nonverbal conditions in five grades.

Condition		Grade					
		4	5	6	10	12	Total
A_1V_1	$\bar{X}$	26.87	30.91	32.54	43.00	40.07	34.11
	s	12.81	12.61	13.87	11.18	12.90	
	N	55	55	55	55	29	249
A_1	$\bar{X}$	20.38	21.95	26.18	39.39	41.06	28.75
	s	10.44	11.47	13.05	11.47	12.10	
	N	55	55	55	56	31	252
V_1	$\bar{X}$	19.84	34.93	32.83	43.39	47.04	34.50
	s	9.66	14.33	13.55	12.28	9.05	
	N	55	55	55	59	28	252
Total	$\bar{X}$	22.36	29.26	30.52	41.95	42.64	
	N	165	165	165	170	88	

Table 3.8. Means and standard deviations of the number of correct responses for the three nonmeaningful-verbal conditions in four grades.

Condition		Grade				
		4	5	6	10	Total
A_2V_2	$\bar{X}$	21.36	23.60	30.27	38.86	29.01
	s	11.06	13.46	14.25	11.31	
	N	55	55	55	66	231
A_2	$\bar{X}$	16.27	24.16	24.07	39.27	22.98
	s	9.91	12.91	12.45	14.94	
	N	55	55	55	15	180
V_2	$\bar{X}$	23.53	25.56	30.29	41.22	29.68
	s	11.81	12.44	13.07	11.09	
	N	55	55	55	59	229
Total	$\bar{X}$	20.39	24.44	28.21	39.90	
	N	165	165	165	140	

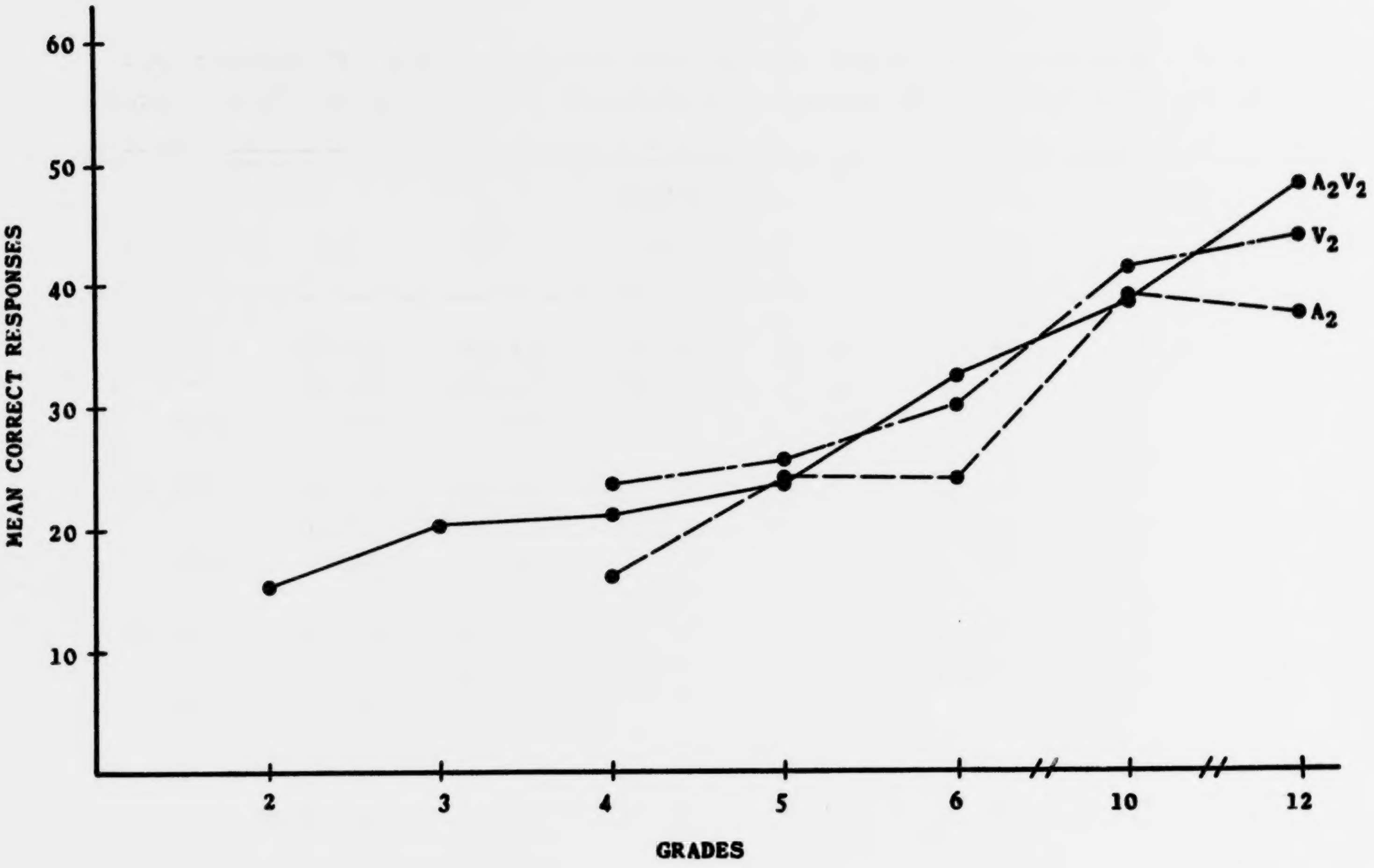


Fig. 3.5 Mean correct responses for Conditions A_2, V_2, & A_2V_2; by grades.

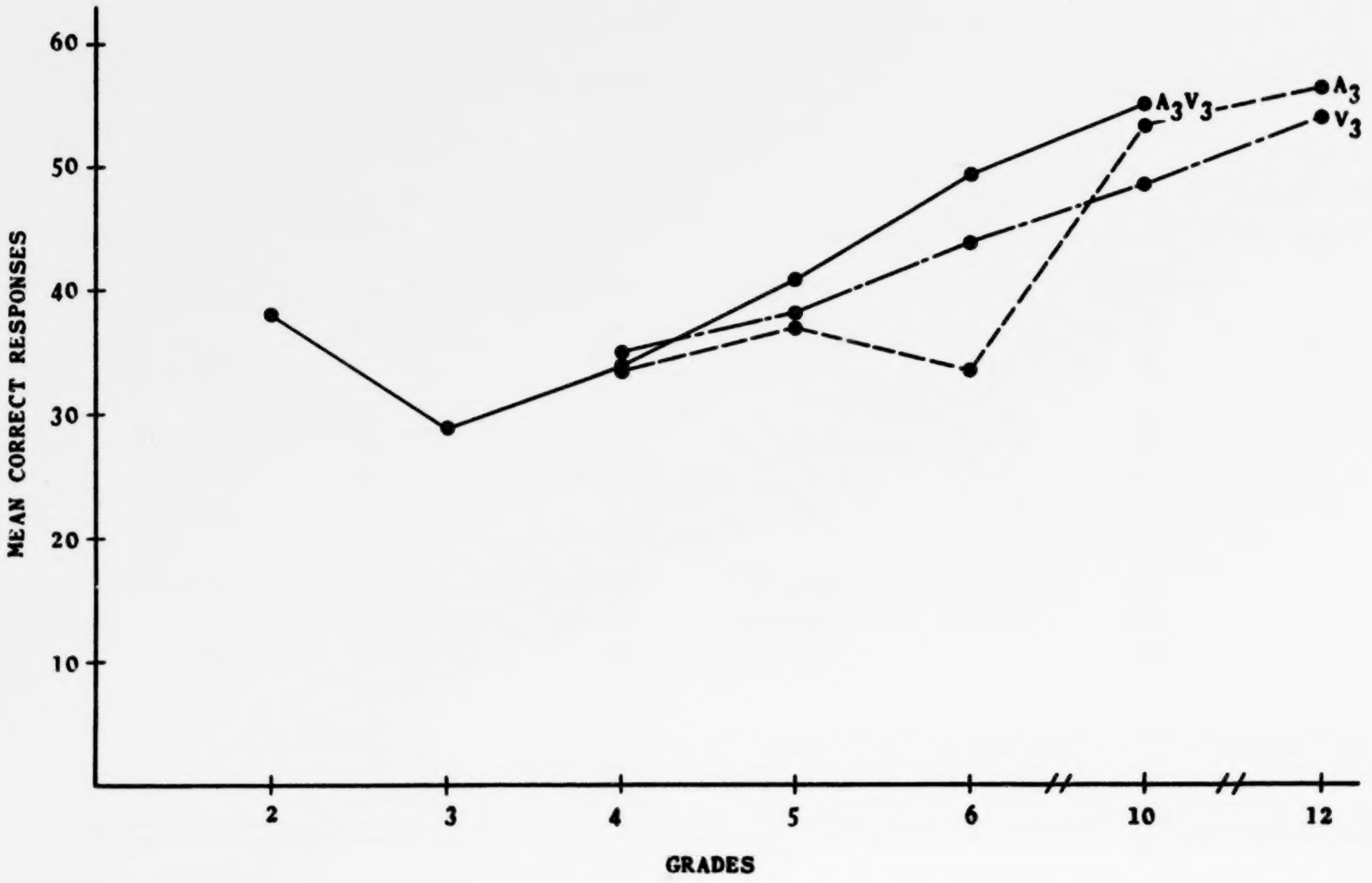


Fig. 3.6 Mean correct responses for Conditions A_3, V_3, & A_3V_3; by grades.

Table 3.9 gives the scores for the meaningful-verbal material, and Figure 3.6 (p. 70) represents the same material graphically. There is a suggestion in these data that the combined presentation might be superior to the unimodal presentations. However, for most of the grades the material was probably too easy to be a good test of the relationships.

Table 3.9. Means and standard deviations of the number of correct responses for the three meaningful-verbal conditions in four grades.

Condition		Grade				Total
		4	5	6	10	
A_3V_3	$\bar{X}$	33.33	40.98	49.18	55.23	45.18
	s	14.67	12.72	11.49	6.33	
	N	55	55	55	66	231
A_3	$\bar{X}$	33.75	36.85	33.64	53.27	38.72
	s	14.35	13.92	15.40	8.31	
	N	55	55	55	45	210
V_3	$\bar{X}$	34.98	38.00	43.91	48.80	41.25
	s	13.35	14.33	9.70	11.94	
	N	55	55	55	50	215
Total	$\bar{X}$	34.02	38.61	42.24	52.64	
	N	165	165	165	161	

For instance, if all the children made correct responses on all ten trials, the maximum score achieveable would be 60.0. To accomplish this, all six items would need to have been correct on the first learning trial. Examination of the table reveals that the tenth grade had one score of 55.23 and another of 53.27. Because the task was so easy, it is likely that many of the children became bored with the task. It was noted that on some of the combined trials the children would look out of the window or close their eyes in what appeared to be an attempt to test themselves on listening alone. If this kind of mental set were at all prevalent among the children, it would be expected to add interest to the task and to improve the final scores. Therefore, even though certain of the scores obtained here would suggest better performance with a combined condition, the evidence obtained continues to suggest that these particular findings must be interpreted with extreme caution.

4. Analysis of combined and mixed conditions across grades. Table 3.10 presents the means and standard deviations for the nine combined conditions in which the three levels of meaningfulness and verbalness are paired across auditory and visual methods of presentation in all possible combinations. Analysis of variance was computed on the nine conditions for grades 2, 3, 4, 5, 6, and 10. Grade 12 was not included in this analysis since all cells were not filled. Table 3.11 presents a summary of this analysis. It indicates that both main effect, conditions and grades, are highly significant. Examination of the marginal totals reveals the previously discussed improvement in scores across grades and the wide differences among conditions when each one is averaged across all grades. However, since the interaction term was significant, the main effects could not be interpreted simply.

Instead of doing analyses of simple effects for the conditions and grades singly, a series of analyses of variance were carried out on certain of the combined conditions while holding a level of meaningfulness constant. These analyses are discussed in the following sections.

5. Auditory NMNV held constant. Figure 3.7 (p. 75) presents graphically the mean learning scores for Conditions A_1V_1, A_1V_2, and A_1V_3

Table 3.10. Means and standard deviations of the number of correct responses for the nine combined conditions in seven grades.

Combined					Grade				
Conditions		2	3	4	5	6	10	12	Total
A_1V_1	$\bar{X}$	20.9	22.4	26.9	30.9	32.5	43.0	40.0	31.9
	s	8.0	10.1	12.8	12.6	13.9	11.2	12.9	
	N	24	29	55	55	55	55	29	302
A_1V_2	$\bar{X}$	17.0	19.3	23.7	23.9	27.8	42.7	42.1	27.4
	s	12.6	10.2	11.5	10.7	12.7	10.0	11.0	
	N	29	31	55	55	55	38	28	291
A_1V_3	$\bar{X}$	23.6	25.5	28.6	35.0	43.9	48.5	50.4	37.4
	s	12.7	8.8	40.0	14.8	12.8	8.3	7.2	
	N	35	26	55	55	55	65	26	317
A_2V_1	$\bar{X}$	15.3	18.5	26.6	25.6	28.0	43.7	39.6	26.6
	s	8.1	8.2	12.3	9.5	11.8	9.6	11.4	
	N	31	51	55	55	55	25	24	296
A_2V_2	$\bar{X}$	15.2	20.2	21.4	23.6	30.3	38.9		26.7
	s	10.4	10.4	11.1	13.5	14.3	11.3		
	N	29	30	55	55	55	66		290
A_2V_3	$\bar{X}$	16.7	16.5	23.1	32.9	33.2	41.4		28.8
	s	6.7	10.0	11.7	12.4	13.1	12.0		
	N	34	37	55	55	55	56		292
A_3V_1	$\bar{X}$	26.0	34.9	39.6	40.3	40.3	50.7	52.3	40.4
	s	11.9	15.4	13.3	11.4	12.6	7.7	9.5	
	N	51	31	55	55	55	60	28	335
A_3V_2	$\bar{X}$	24.1	29.7	32.6	29.7	37.4	45.7		33.3
	s	11.0	17.8	13.6	15.4	10.8	7.5		
	N	35	39	55	55	55	39		278
A_3V_3	$\bar{X}$	38.1	28.9	33.3	41.0	49.2	55.2		42.7
	s	14.5	13.9	14.7	12.7	11.5	6.3		
	N	28	32	55	55	55	66		291
Total	$\bar{X}$	21.9	23.6	28.4	31.4	35.9	45.9	44.9	33.0
	N	296	306	495	495	495	470	135	2692

Table 3.11. Summary of the analysis of variance for nine combined conditions and six grades.

Source	df	MS	F
Conditions (C)	8	9032.75	64.09**
Grades (G)	5	29240.50	207.46**
C x G	40	369.33	2.62**
Within Cell	2503		

$^{**}p < .01$

across grades, thus holding constant the auditory NMNV component. An orderly progression of learning scores within increasing grade levels is evident. However, the subjects consistently performed better across grades, with Condition A_1V_1 than with Condition A_1V_2. The only exception to the trend is minor and involves a slight reversal in performance for grade 12 in which A_1V_2 is higher than A_1V_1. An analysis of variance was computed for the three conditions across grades. Table 3.12, which summarizes the results of this analysis, indicates that both main

Table 3.12. Summary of the analysis of variance for the three combined conditions, which include A_1, and seven grades.

Source	df	MS	F
Conditions (C)	2	4954.85	36.03**
Grades (G)	6	11214.78	81.54**
C x G	12	252.33	1.83*
Within Cell	889	137.53	

$^{*}p < .05$; $^{**}p < .01$

effects and the interaction were significant. Therefore, an analysis of simple effects was carried out. Table B.2 in the Appendix B presents a

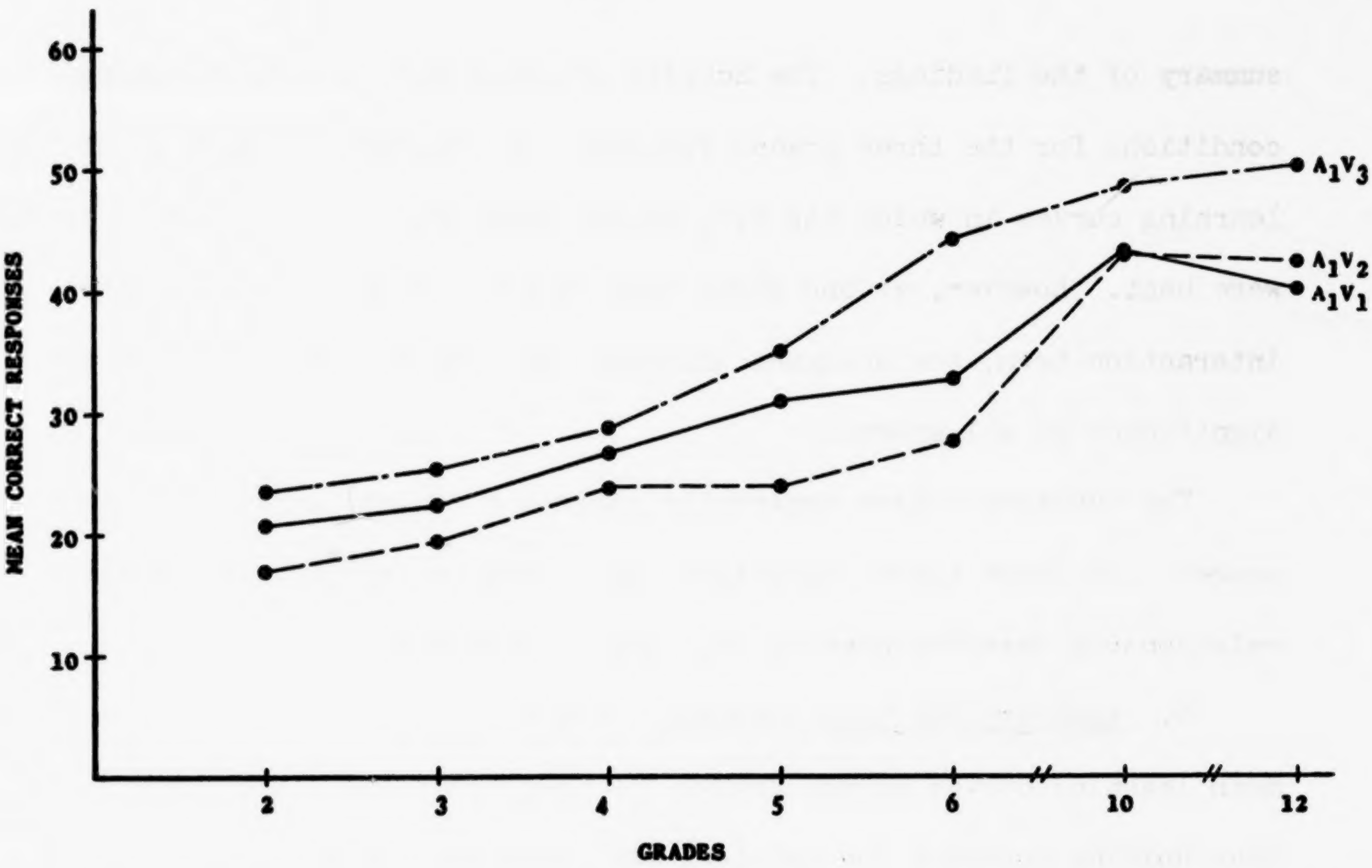


Fig. 3.7 Mean correct responses for Conditions A_1V_1, A_1V_2, & A_1V_3; by grades.

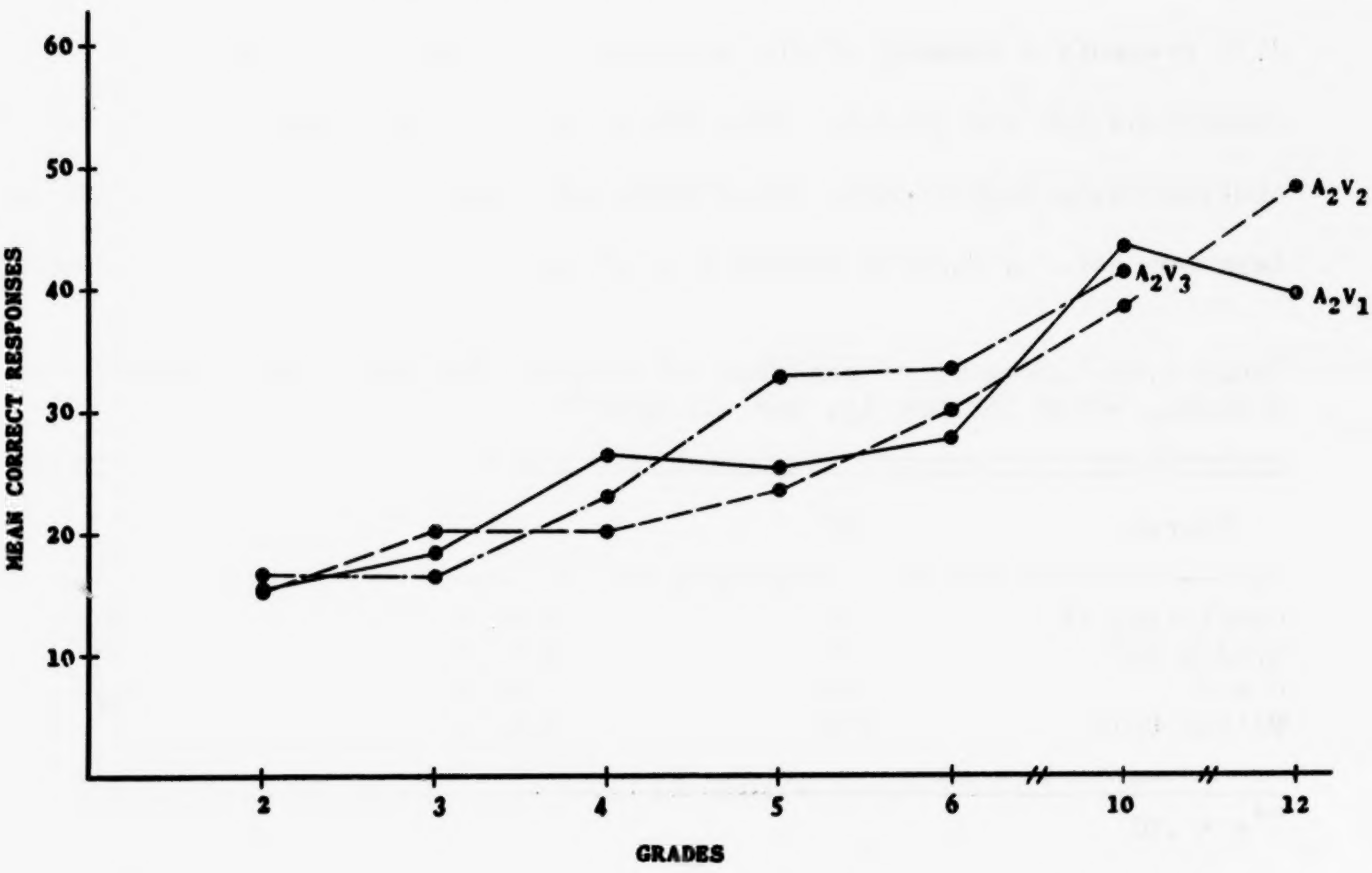


Fig. 3.8 Mean correct responses for Conditions A_2V_1, A_2V_2, & A_2V_3; by grades.

summary of the findings. The Scheffe analysis for differences among conditions for the three grades verified the observations made about the learning curves in which the A_1V_2 scores were poorest and the A_1V_3 scores were best. However, as one might have expected from the significant interaction term, the analyses indicate that these differences are not significant in all grades.

The auditory noises apparently exerted a minimal influence upon the scores. In these three conditions the alignment follows closely the relationship observed when V_1, V_2, and V_3 were presented singly.

6. Auditory NMV held constant. Figure 3.8 (p. 75) represents the mean learning curves across grades for Conditions A_2V_1, A_2V_2, and A_2V_3, thus holding constant the auditory NMV component. Again, there is an orderly increase in scores with higher grade levels, but there is no apparent effect of conditions which is consistent across grades. Table 3.13 presents a summary of the analysis of variance of these three conditions for six grades. Only the effect of grades was found to be statistically significant; the effects of conditions and the interaction term were not. A Scheffe analysis of grades indicates that grades 2 and 3

Table 3.13. Summary of analysis of variance for the three combined conditions, which include A_2, and six grades.

Source	df	MS	F
Conditions (C)	2	370.12	2.86
Grades (G)	5	11136.36	85.98**
C x G	10	344.34	2.66
Within Cell	836	129.53	

**$p < .01$

do not differ from each other, but all other combinations of grades are significant in the expected rank order.

It is interesting to note that, when using an auditory presentation of nonsense syllables, there is no effect of conditions even though there appeared to be a wide range of meaningfulness in the visual modality. This is particularly striking since this same manipulation, but holding auditory NMNV constant, resulted in highly significant effects of conditions. Apparently, the auditory nonsense syllables have greater influence in the total performance than do the nonmeaningful noises.

7. Auditory MV held constant. In order to hold the auditory MV variable constant, Conditions A_3V_1, A_3V_2, and A_3V_3 were compared. Figure 3.9 (p. 78) represents the mean learning scores for these conditions. Except for the high mean for Condition A_3V_2 in grade 2, there is an orderly progression of performance with increasing grade level. The effect of conditions is not as consistent. Condition A_3V_1 appears highest in the lower grades, while for grade 6 and up, subjects appear to perform best with Condition A_3V_3. It is also apparent that Condition A_3V_2 produced the lowest performance scores. Table 3.14 presents the

Table 3.14. Summary of the analysis of variance for the three combined conditions which include A_3, and six grades.

Source	df	MS	F
Conditions (C)	2	4352.35	28.39**
Grades (G)	5	8252.02	58.83**
C x G	10	785.84	5.13**
Within Cell	858	153.31	

**$p < .01$

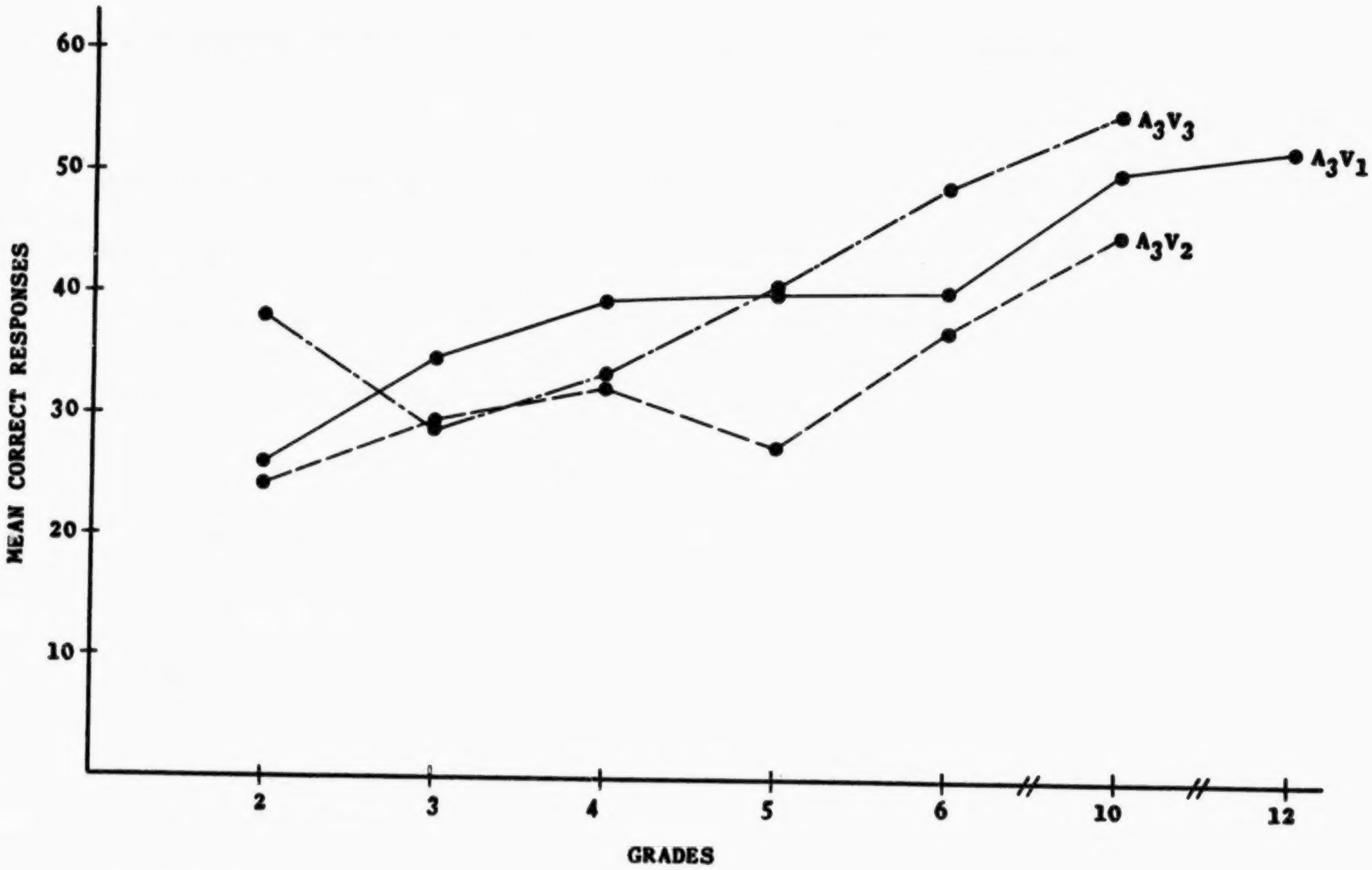


Fig. 3.9 Mean correct responses for Conditions A_3V_1, A_3V_2, & A_3V_3; by grades.

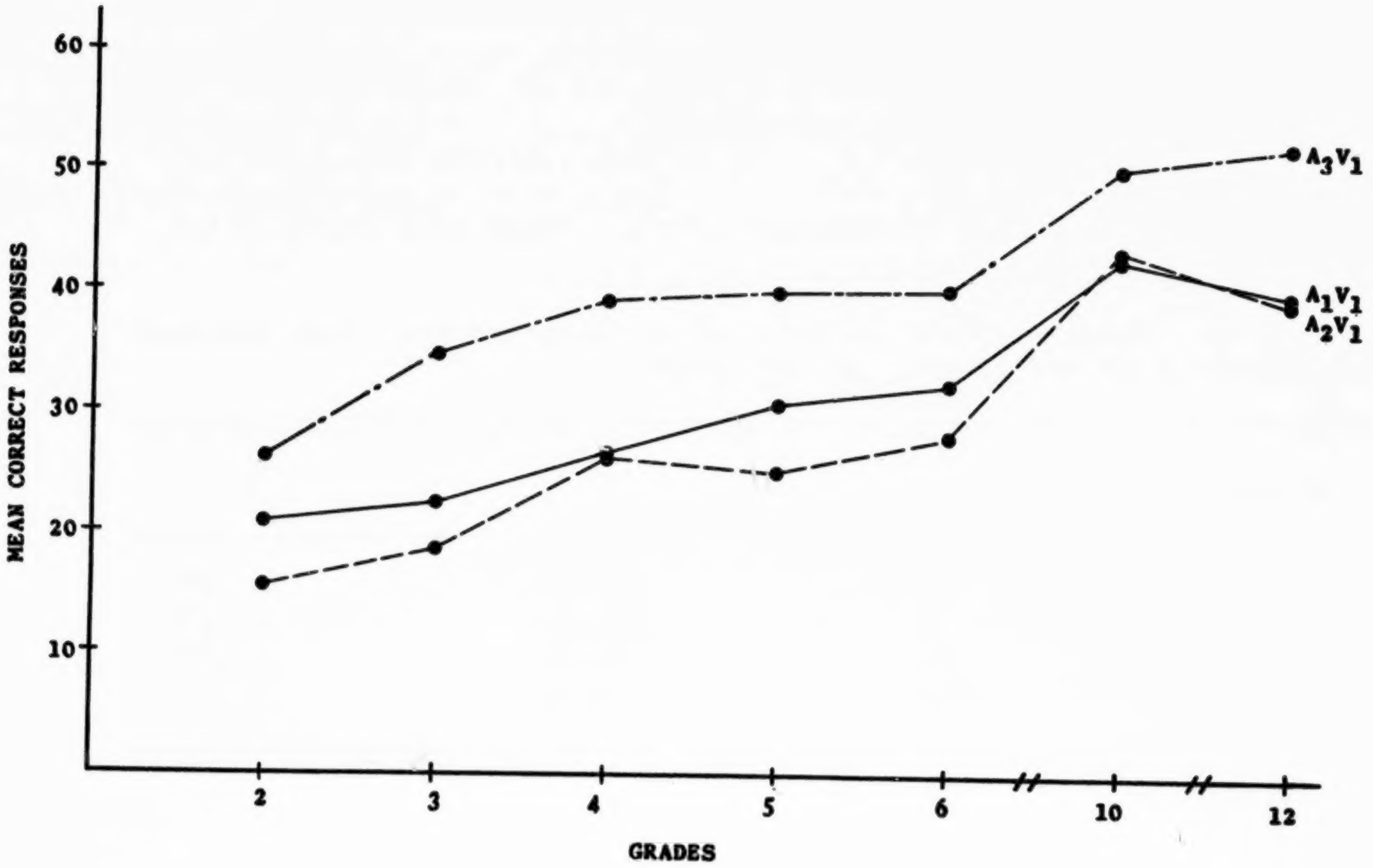


Fig. 3.10 Mean correct responses for Conditions A_1V_1, A_2V_1, & A_3V_1; by grades.

summary of the analysis of variance for these conditions across grades. It indicates that both main effects, conditions and grades, were significant. However, the interaction was also significant; therefore, an analysis of simple effects was done. Table B.3 in the Appendix B presents the summary of the analysis and the results of the Scheffe test. The very conservative Scheffe test indicates that none of the comparisons within a grade across conditions is significant in spite of the fact that some of the analyses of the simple effects were significant at the .001 level. However, the trend from inspection indicates that Condition A_3V_2 is inferior to the other conditions and A_3V_3 is the best. Therefore, the results are considered to be in line with the other findings; i.e., when V_2 is present, the scores are poorer than when V_1 is used.

8. Visual NMNV held constant. To hold the visual NMNV component constant, Conditions A_1V_1, A_2V_1, and A_3V_1 were compared across grades. Figure 3.10 (p. 78) represents the mean learning scores for these conditions. The progression of performance with grade level is not as great as in some of the other conditions, probably because the lower grades perform at relatively higher levels. It is also evident that across grades subjects performed best with Condition A_3V_1, and Condition A_1V_1 appears slightly better than Condition A_2V_1 especially in the lower grades.

Table 3.15 presents a summary of the analysis of variance on the data for seven grades and these three conditions. Both main effects, but not the interaction, were significant. The Scheffe analysis indicates that when the effects of grades are pooled, the three conditions are all significantly different from each other.

Table 3.15. Summary of the analysis of variance and of the Scheffe tests for the three combined conditions, which include V_1, and seven grades.

Source	df	MS	F
Conditions (C)	2	1860.62	14.15**
Grades (G)	6	9803.21	74.54**
C x G	12	156.16	1.19
Within Cell	912	131.52	
$\overline{X}$	26.60	31.94	40.38
Conditions#	A_2V_1	A_1V_1	A_3V_1

$\overline{X}$	21.75	24.07	31.02	32.27	33.64	44.15	46.41
Grades#	2	3	4	5	6	12	10

$^{**}p < .01$. #Lines connect nonsignificant differences at $p = .01$.

It is interesting to note that in both conditions involving nonmeaningful-nonverbal material, the inclusion of a nonmeaningful-verbal component (either A_2 or V_2) results in a significant decrement in the performance observed under the base conditions, A_1 or V_1. However, the inclusion of meaningful-verbal material (A_3 or V_3) results in significant improvement in the performance.

9. Visual NMV held constant. The mean learning scores for Conditions A_1V_2, A_2V_2, and A_3V_2 across grades are presented in Figure 3.11 (p. 81). The performance with Condition A_3V_2 is superior to the other conditions which are not noticeably different from each other. Table 3.16 presents a summary of the analysis of variance on these data for six grades. Both main effects, but not the interaction, were significant. The Scheffe test indicates that across grades A_1V_2 and A_2V_2 do

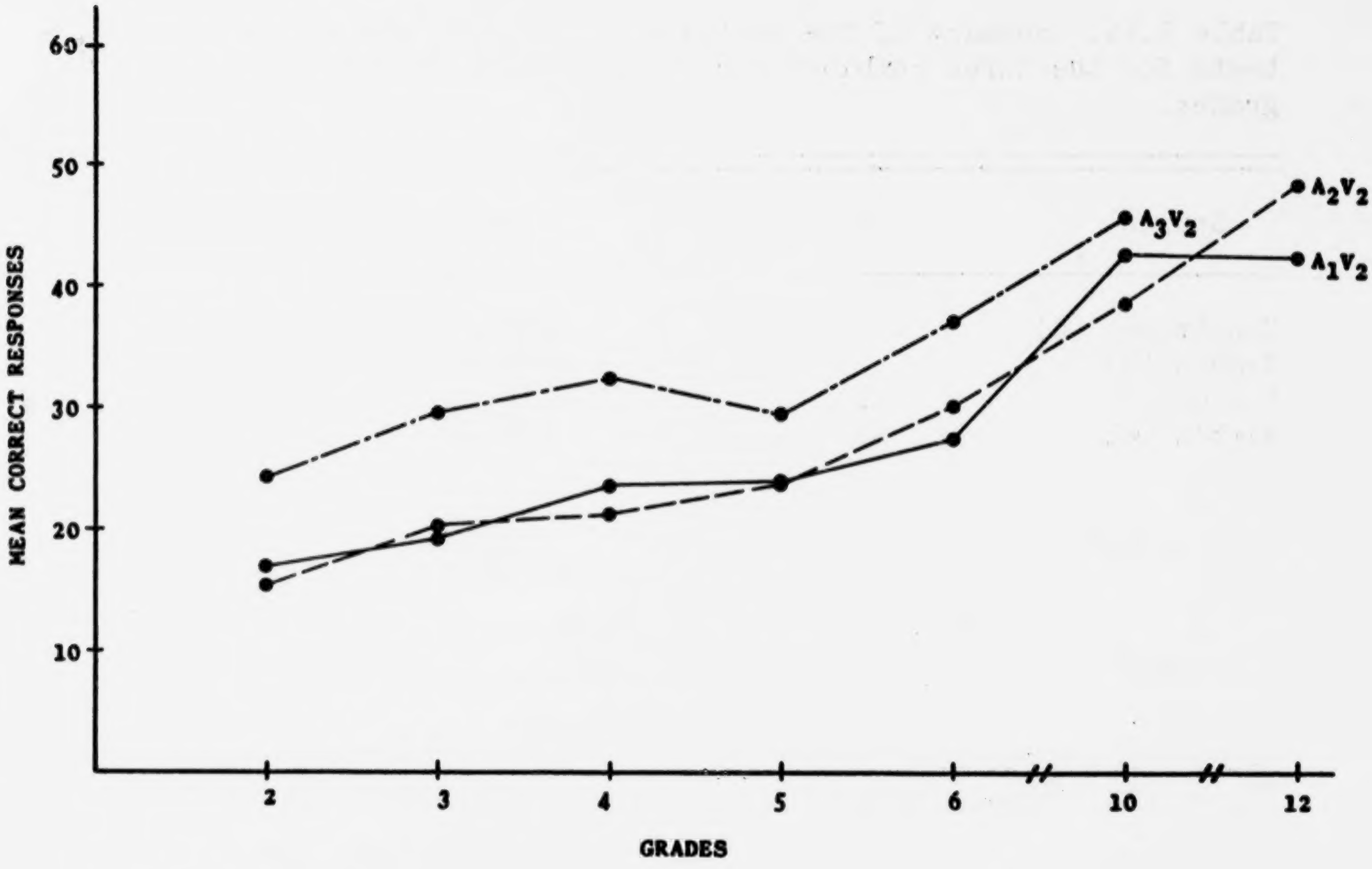


Fig. 3.11 Mean correct responses for Conditions A_1V_2, A_2V_2, & A_3V_2; by grades.

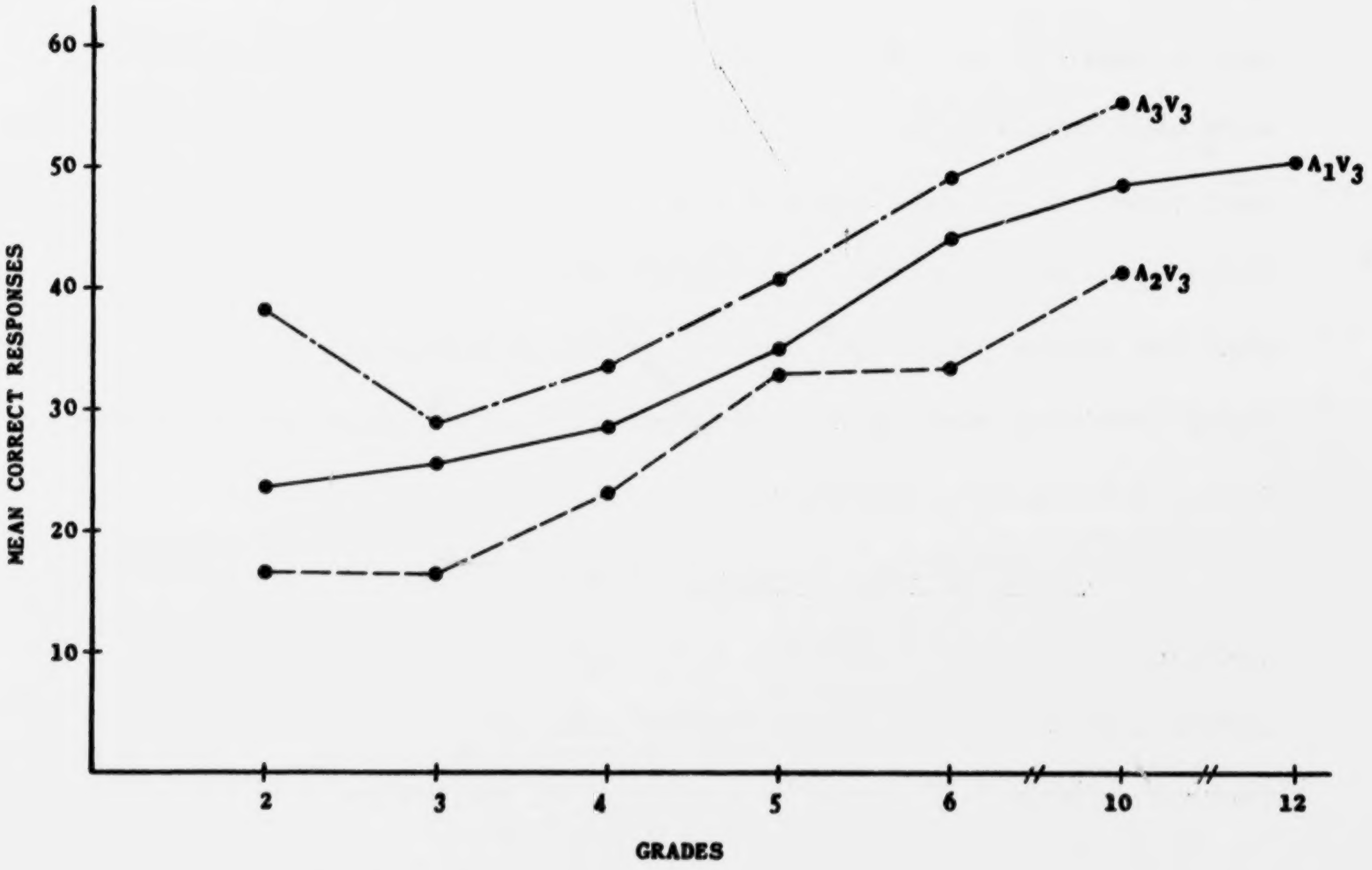


Fig. 3.12 Mean correct responses for Conditions A_1V_3, A_2V_3, & A_3V_3; by grades

Table 3.16. Summary of the analysis of variance and of the Scheffe tests for the three combined conditions, which include V_2, and six grades.

Source	df	MS	F
Conditions (C)	2	5379.20	35.75**
Grades (G)	5	8798.78	58.48**
C x G	10	118.60	.79
Within Cell	813	150.46	

$\overline{X}$ Conditions#	25.84	26.73	33.35
	A_1V_2	A_2V_2	A_3V_2

$\overline{X}$ Grades#	18.43	23.65	25.74	25.87	31.82	41.75
	2	3	5	4	6	10

$^{**}p < .01$. #Lines connect nonsignificant differences at $p = .01$.

not differ significantly from each other, but that A_3V_2 is significantly better than either of them. In the present comparison A_3V_2 is significantly superior to A_1V_2 and A_2V_2. In section 6 in which comparisons were made involving A_2, the conditions did not differ significantly from each other; i.e., A_2V_3 was not significantly better. Reference back to Table 3.10 indicates that the scores under Condition A_3V_2 are better than the scores under A_2V_3 for all grades except grade 5. Of all conditions involving meaningful-verbal material, the scores across grades are lowest for the A_2V_3 condition.

10. Visual MV held constant. Figure 3.8 (p. 75) presents the mean learning scores for Conditions A_1V_3, A_2V_3, and A_3V_3 across grades. The curves indicate that the performance with A_3V_3 is best and with A_2V_3 is poorest. Table 3.17 presents a summary of the analysis of variance for

these data and indicates that both main effects and the interaction are significant. Therefore, a simple effects analysis was carried out and is summarized in Table B.3 in Appendix B. These analyses confirm the conclusions drawn about the figure; i.e., that the condition involving the auditory pronunciation of nonsense syllables is inferior to the one utilizing the auditory noises.

Table 3.17. Summary of the analysis of variance for the three combined conditions, which include V_3, and six grades.

Source	df	MS	F
Conditions (C)	2	12523.06	88.82**
Grades (G)	5	12859.70	91.20**
C x G	10	345.63	2.45**
Within Cell	856	141.00	

**$p < .01$

11. Combined conditions with equivalent levels of meaningfulness in both modalities. In Conditions A_1V_1, A_2V_2, and A_3V_3, the same type of material was presented both visually and auditorily. Figure 3.13 (p. 84) presents the mean learning scores for the conditions across grades and indicates that Condition A_3V_3 is consistently superior. The performance of grade 2 on A_3V_3 is better than would have been predicted. However, in general, the data follow the trends observed in other analyses; i.e., the fully meaningful material produces the best scores and the nonsense syllables produce the poorest scores. Table 3.18 presents a summary of the analysis of variance for these data. Since both main effects and the interaction were significant, an analysis of simple

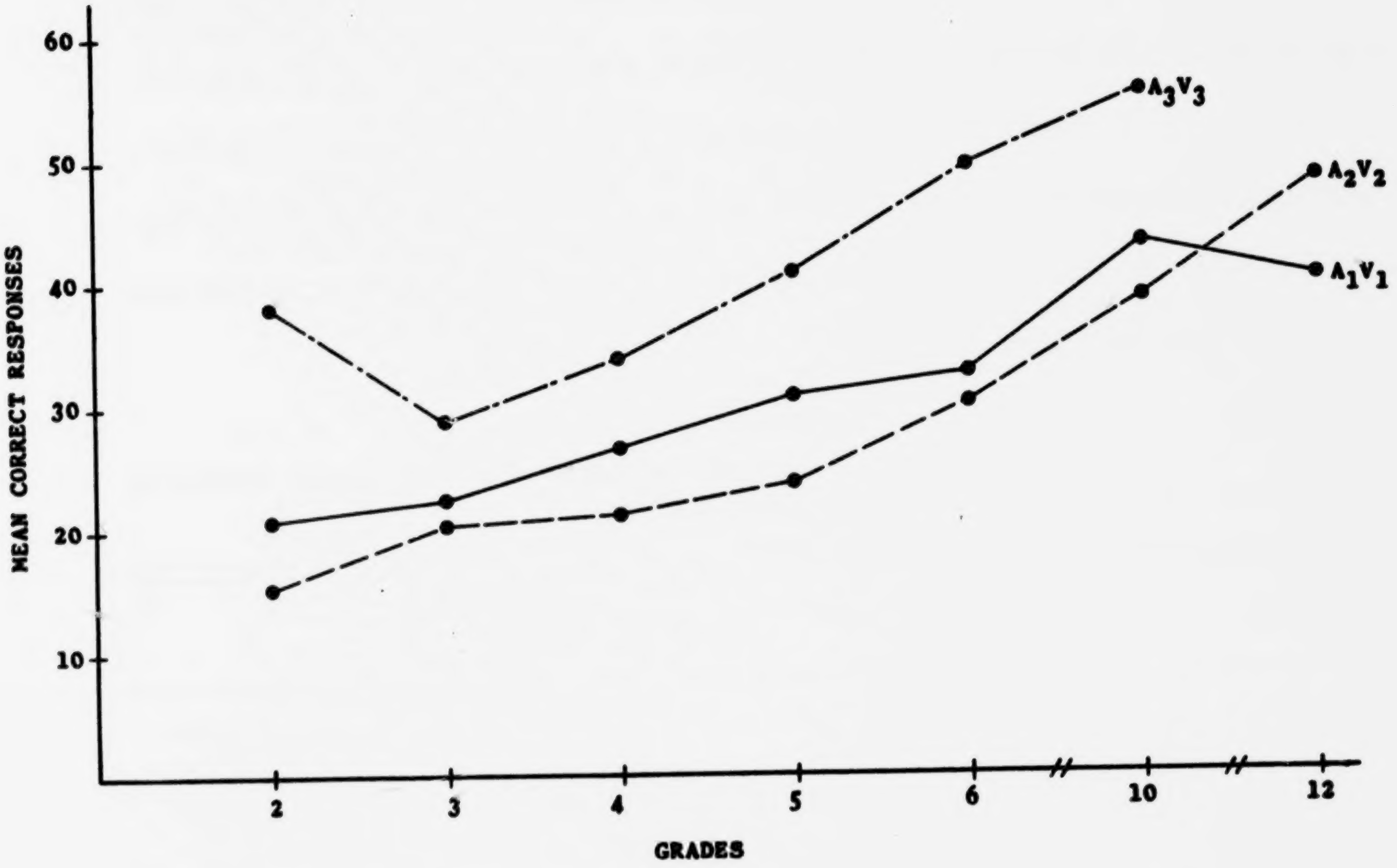


Fig. 3.13 Mean correct responses for Conditions A_1V_1, A_2V_2, & A_3V_3; by grades.

Table 3.18. Summary of the analysis of variance for the three combined conditions, which have equivalent levels of meaningfulness in both modalities, and six grades.

Source	df	MS	F
Conditions (C)	2	17446.99	119.12**
Grades (G)	5	9150.80	62.48**
C x G	10	370.95	2.53**
Within Cell	836	146.47	

**$p < .01$

effects was also carried out. Table B.4 in Appendix B presents a summary of the follow-up analyses.

The simple analyses reveal that the three conditions differ among each other at all grade levels. Consistently, the meaningful-verbal material was easiest and the nonmeaningful-verbal material was most difficult.

D. Summary and Conclusions: Part I

The following conclusions emerge from the analyses of the data gathered as part of Experiment III.

1. There is improvement in the learning scores from grade 2 through grade 10. When the data from all conditions are pooled, there is a regular progression of about three units per grade from grade 2 through grade 10 with grade 12 showing only slight further improvement. When analyses were carried out on the separate types of materials utilized, there were a few instances of inversion in rank order of grade level, but in no case was there a significant difference in which a lower grade performed better than a higher grade.

2. Bimodal presentation of material was not superior to unimodal presentations. With the possible exception of the meaningful-verbal material in which for some grades there was almost one-trial learning, the results again show that a bimodal presentation of stimuli is not superior to the better of the unimodal presentations. Where the two unimodal presentations differ, the bimodal presentation is usually equivalent to the better of the single presentations. This finding is in keeping with our earlier research and suggests that with normal children the use of a bimodal presentation does not produce interference; it simply does not result in improvement in performance.

3. Meaningfulness of material appears to be the most important variable. Table 3.19 presents the fifteen conditions in rank order according to the mean correct responses for grades 4, 5, 6, and 10.

Table 3.19. The fifteen conditions arranged in rank order by mean correct responses for grades 4, 5, 6, and 10.

Rank	Condition	$\overline{X}$	Rank	Condition	$\overline{X}$
1	A_3V_3	44.67	9	A_2V_3	32.72
2	A_3V_1	42.72	10	A_2V_1	30.98
3	V_3	41.42	11	V_2	30.15
4	A_3	39.38	12	A_1V_2	29.52
5	A_1V_3	39.00	13	A_2V_2	28.55
6	A_3V_2	36.35	14	A_1	27.00
7	A_1V_1	33.32	15	A_2	25.98
8	V_1	32.72			

These four grades were used because all fifteen conditions had been presented to them and because the trends which occurred within these grades were fairly typical of all the results. Other types of analyses on these data indicate that differences between means of less than about five or six units are not generally statistically significant.

In the fifteen conditions each of the three levels of meaningfulness are represented eight times either singly or in combination. The superiority of the meaningful-verbal component is illustrated by the fact that seven of the eight possible occurrences of A_3 and V_3 appear in the first six ranks. The fact that the nonmeaningful-verbal material was the most difficult is shown by the fact that seven of the possible eight occurrences appear in the lowest seven ranks. Apparently, the nonmeaningful-nonverbal material had the least overall influence since one or another of these components appear all the way from rank two down to rank fourteen. In spite of the fact that there is fairly clear evidence that the A_1 material was more difficult than the V_1 material, the fact that meaningfulness is undoubtedly far more important than the sensory channel of presentation is illustrated by the distribution of the method of presentation. In the conditions there are twelve utilizations of the auditory presentations and six of them appear in the first seven ranks and six in the last seven. Of the twelve visual presentations, six occur in the first seven ranks and six occur in the last eight ranks.

The most important single conclusion which emerges from this table and from the other analyses is the fact that the type of material being presented is more important than the channel or channels through which it is presented.

E. Results: Part II

Comparisons made between a simple combined condition such as A_3V_3 and a mixed condition such as A_3V_1 allow some inferences to be drawn about the effect of the V_1 component in the total learning scores. However, it gives no indication of whether the individual children were utilizing the V_1 component as part of the total stimulus complex or perhaps were ignoring it. In an attempt to get more information on these aspects of the performances, an "eleventh-trial analysis" was planned. Specifically, utilizing two groups of subjects for the standard ten trials on a condition such as A_3V_1, an eleventh trial was administered to each of the groups. For one sample, only the A_3 material was presented; for the other sample, only the V_1 material was presented. If all children were attending fully to the A_3 material and ignoring the V_1 material, the scores on the eleventh trial with A_3 should be as good as or better than the scores on the tenth trial when A_3V_1 was presented. Conversely, the scores on V_1 should be near zero for the eleventh trial. The procedure involving two samples was used for grades 4, 5, and 6. However, because of a limitation in the number of samples available for grades 10 and 12 a modified procedure was employed. In these instances, all subjects were given the 12 stimuli in sequence upon completion of the tenth trial. Half of the groups had the six visual stimuli presented first, and half the six auditory presented first.

It was found that for certain conditions, particularly those involving A_3 and V_3, the higher grades learned the material in a very few trials, making it difficult to obtain data concerning modality preference after 10 trials. Therefore, for Condition A_3V_1 in the twelfth grade and for

Condition A_3V_3 in the tenth grade, the switch to the test involving single modalities was made after the fifth learning trial and the data analyzed accordingly. It is likely that many of the children in other grades and conditions learned the meaningful-verbal component fairly early in the learning trials and in some instances had then devoted their attention to the more difficult component. Certainly, the switch to single modalities was made at different levels of learning for the various conditions and the various grades. However, the study was not designed originally for the eleventh-trial analysis, but the eleventh trial was added with the intent of obtaining as much information as possible from the total task.

1. Results for grades 4, 5, and 6. Table 3.20 presents the mean correct responses on the tenth trial for each of the two samples and the mean for one sample when the eleventh trial was auditory and for the second sample when the eleventh trial was visual. The last column in the table presents the difference in the mean correct responses for the eleventh trial when the score for the auditory presentation is subtracted from the score for the visual presentation. A variety of statistical comparisons were carried out on the data recorded in the table. As might be expected, some of the paired samples differed significantly from each other in their performance on the tenth trials even though they were receiving exactly the same material. Where the two samples differed in this basic fashion, an indication is placed in the grade column. Correlated t-ratios were utilized to determine whether the change in performance from the tenth to the eleventh trial was significant. The changes which were found to be statistically significant are indicated by

Table 3.20. Mean correct responses for the 10th trial, combined presentation and two samples per grade; mean correct responses for the 11th trial, one sample with auditory component only and one with visual only; and difference in performances between the two samples on the 11th trial, visual minus auditory.

CONDITION	GRADE	SAMPLE I		SAMPLE II		11th
		10th AV	11th A	10th AV	11th V	V-A
A_1V_1	4	3.94	2.29**	4.36	4.47	+2.18*
	5	3.84	2.74*	4.37	4.30	+1.56**
	6	4.70	3.26**	4.24	3.66*	+ .40
A_2V_1	4	3.85	2.69**	4.34	4.07	+1.38*
	5	4.30	3.11**	4.00	3.62	+ .51
	6	4.34	3.47**	4.08	3.69	+ .22
A_3V_1	4	5.47	5.38	4.97	4.26**	-1.12**
	5#	5.00	5.00	5.70	4.36**	- .64
	6	5.24	5.24	5.50	4.61**	- .63
A_1V_2	4	3.18	2.21**	3.54	3.00*	+ .79
	5	3.82	3.08*	3.32	3.21	+ .13
	6	4.16	3.53*	4.37	4.15	+ .62
A_2V_2	4	3.44	2.88*	3.19	3.45	+ .57
	5#	2.97	2.98	3.78	3.97	+ .99*
	6#	3.91	3.94	4.76	4.82	+ .88
A_3V_2	5	4.69	4.74	4.00	2.69**	-2.05*
	6#	5.80	5.83	5.06	4.31*	-1.52**
A_1V_3	4#	3.47	2.28**	3.09	4.11**	+1.83**
	5	4.67	2.71**	4.78	4.97	+2.26**
	6	5.24	3.26**	5.08	5.03	+1.77**
A_2V_3	4	3.82	1.27**	2.70	2.85	+1.58*
	5	4.82	1.97**	4.65	4.71	+2.74**
	6	4.73	1.85**	4.97	4.97	+3.12**
A_3V_3	4	4.97	5.14	4.77	4.23**	- .91
	5	5.13	5.28	5.38	5.31	+ .03
	6	5.59	5.23*	5.89	5.89	+ .66

*$p < .05$; **$p < .01$. #Sample means for the 10th trials of Sample I and Sample II differed significantly at the .05 level.

asterisks in the column for the eleventh trial. Likewise, when the difference between the auditory and visual performances on the eleventh trial differed from each other, indication is made in the final column on the table.

In general, it was found that there was a numerical decrement in the learning scores from the tenth trial to the eleventh trial. This decrement might possibly be explained on the basis of a shift in the stimulus condition between the two trials which in some way interfered with the learning for some of the children. However, other researchers (Berlyne, 1950; Montgomery, 1954, and White, 1959) have reported that the change lends impetus to such factors as "novelty" and "curiosity" which have been shown to affect performance favorably. Another possibility is that certain children were selective in their use of stimulus components such that for the six stimuli involved in A_3V_1 they were using five of the items from the A_3 list and one item from the V_1 list. The design of the study was not such as to permit determination of these factors.

Examination of the table reveals that in general significant drops in performance were found when the shift on the eleventh trial involved a list that was basically more difficult or was less meaningful. For example, in A_1V_1 the shift to A_1 revealed a significant decrement while the shift to V_1 did not. When A_3 was part of the combined presentation and the shift was to A_3 on the eleventh trial only one decrement out of a possible eight was found to be significant. Likewise, for V_3 there was only one significant decrement out of nine possible.

The eleventh-trial analysis tends to confirm the results discussed for the first ten trials; however, it adds basic information. Examination of Condition A_1V_1 indicates that all three shifts to A_1 resulted in significant decrements while only one shift to V_1 was significant. In this instance other results have indicated that the material for A_1 was basically more difficult than V_1. The difference would appear to be primarily related to level of difficulty of the material. This observation is even more clear in the A_2V_1 condition in which the scores on A_2 have been consistently less than on V_1. Here all three shifts to A_2 were significant and none of the three to V_1 were. In A_3V_1 none of the shifts to A_3 were significant while all three shifts to V_1 were. It is interesting to note Conditions A_2V_2 and A_3V_3. Basically, there is no consistent trend for the shift to either modality to result in significant decrement.

In general, it can be seen that with few exceptions what would appear to be a preference for a given modality might more parsimoniously be attributed to the influence of meaningfulness or difficulty of the individual lists.

2. Results for grades 10 and 12. As has been mentioned, a slightly different procedure was used for grades 10 and 12 since only one sample was available per condition. For these grades the eleventh trial consisted of the presentation of the six auditory or the six visual components first followed immediately by the opposite component. The statistical analyses made utilized the t-ratio for correlated scores. Table 3.21 presents the mean correct responses for the tenth trial and the mean number of correct responses obtained on the eleventh trial for the visual and the auditory components. Significant changes between the

tenth and eleventh trials are indicated by asterisks. The last column in Table 3.21 gives the signed difference between the scores obtained from the visual stimuli and the auditory stimuli. Again, significant differences are indicated by asterisks.

Table 3.21. Mean correct responses for the tenth trial, combined presentation; mean correct responses for the auditory and visual stimuli on the eleventh trial; and differences in performances between the two sets of stimuli, visual minus auditory.

Condition	Grade	Trials 10th AV	 11th A	 11th V	V-A
A_1V_1	12	5.55	3.93**	5.28	+1.35**
A_2V_1	10	5.76	4.68**	5.00*	+ .32
	12	5.08	4.42	4.50	+ .08
A_3V_1	12	5.75	5.61	4.71**	- .90**
A_1V_2	10	5.71	3.58**	5.11*	+1.53**
	12	5.57	3.89**	5.54	+1.65**
A_2V_2	10	5.45	5.38	5.36	- .02
	12	5.75	5.71	5.58	- .13
A_3V_2	10	5.85	5.67	4.90**	- .77*
A_1V_3	12	5.92	4.23**	5.73	+1.50**

*$p < .05$; **$p < .01$; A or V is significantly different from AV or A and V are significantly different on trial 11.

In general, the results obtained from the tenth and twelfth grades agree quite closely with those obtained from the fourth, fifth, and sixth grades. Almost without exception there is some decrement in the performance on the eleventh trial. Again, it would appear that the detrimental effect in changing the stimulus expected to accrue from the novelty of the revised situation. When a meaningful-verbal component was included and the shift was to this component, the drop in performance was always slight and was never significant. When the visual or auditory components were found from other analyses to be of different difficulties when tested singly, the shift to the less difficult component resulted in the least decrement. When the two components were of approximately equal difficulty as in A_2V_2, neither shift resulted in a significant drop in performance.

Although the data were gathered under slightly different circumstances, the results obtained with the tenth and the twelfth grades tend to extend the conclusions drawn from the data obtained on grades 4, 5, and 6.

Experiment IV

Learning in Grades Five and Six; Two Conditions

ABSTRACT. Verbal material at two levels of meaningfulness was presented by one modality (auditory or visual) for one half of the experiment, and then by the other modality for the other half. Results indicate that changing modalities had no marked effect on the overall performance. However, a temporary decrement in learning was noted with nonmeaningful-verbal material when the visual modality preceded the auditory.

A. Introduction

One of the basic problems under study in the present research concerns the relationships of auditory, visual, and combined audio-visual methods of presentation to learning scores. The evidence has pointed to a general equivalence of the auditory and the visual methods of presentation when the material is verbal. Furthermore, with only an occasional exception, the combined method of presentation has not been superior to the better of the single methods of presentation. At the outset of the present project, it was assumed that these findings needed to be limited to verbal material that was also highly meaningful. However, in Experiment III the same general trends were found with nonmeaningful-verbal material; i.e., nonsense syllables. For instance, in grades 5 and 6 when nonsense syllables were presented auditorily, the scores were 24.16 and 24.07. When the same material was presented visually, the scores were 25.56 and 30.29, and when presented audio-visually, the scores were 23.60 and 30.27. For the fifth grade, there is no difference among the are less, but the combined and visual scores do not differ from each other. Results of this type, along with the finding that meaningfulness was more important than modality in the presentation of mixed conditions in Experiment III, leads to the hypothesis that one might change modality of presentation in the middle of a task without any serious effect upon the ultimate learning score.

Two basic procedures were used in the present project for assessing "modality preference" and learning. As reported in Experiment III, an eleventh-trial analysis was done on the combined trials to determine which of the single reception channels was contributing the greater amount to the final learning score. This was considered an indirect attack upon the problem. However, the evidence indicated that channel preference was primarily a matter of meaningfulness. In Experiment IV, a direct attack was planned upon the problem. Specifically, meaningful-verbal and nonmeaningful-verbal material was presented via a single channel for five trials and without interruption to the other channel for five trials. Since meaningfulness should be equivalent in the separate conditions and since it might be assumed that implicit pronunciation would occur in the visual conditions, it was hypothesized that the scores would not be altered appreciably by this procedure nor would they differ significantly whether the first five trials were visual or auditory. It seemed likely to assume that the same mediator would be employed by the subjects regardless of the modality utilized.

B. Experimental Procedures

A counterbalanced design was employed to evaluate the effect of a change from one modality to another within a task. The standard procedure (alternate learning and test trials for a total of ten test trials) was used; however, the first five trials were either auditory or visual and the last five trials used the opposite modality. Both nonsense syllables and meaningful words were tested in this manner using subjects from the fifth grade; only nonsense syllables were used with the sixth grade. The experimental conditions were identified as A_2-V_2, V_2-A_2, A_3-V_3, and V_3-A_3 in which the letters and subscripts have the same meaning as used previously but the hyphenation indicates that the modalities were used in the order shown.

C. Results and Discussion

The mean number of correct responses, the standard deviations, and the sample sizes for the fifth and sixth grades are presented by blocks of trials and by total performance in Table 4.1. Inspection of the data indicates that changing modalities from auditory to visual or visual to auditory between the fifth and sixth trial does not produce a marked differential effect. The scores for comparable blocks of trials involving a given grade level or level of meaningfulness are highly similar. The main difference in performance is related to the levels of meaningfulness.

While it was possible that the shifting from auditory to visual or visual to auditory would not result in a difference in the performance, it was equally possible that both shifts produced comparable reductions in total performance. No conditions were included as part of this experiment in which a single modality was utilized throughout the ten

Table 4.1. Means and standard deviations of the number of correct responses when sensory method of presentation was shifted between trials 5 and 6.

				TRIALS		
Grade	Condition	N		1-5	6-10	Total
5	A_2-V_2	22	$\bar{X}$	8.82	15.91	24.73
			s	4.48	7.58	
5	V_2-A_2	30	$\bar{X}$	10.47	15.57	26.04
			s	5.58	7.22	
6	A_2-V_2	26	$\bar{X}$	10.12	17.00	27.12
			s	5.62	9.52	
6	V_2-A_2	28	$\bar{X}$	10.25	15.46	25.71
			s	6.19	8.92	
5	A_3-V_3	29	$\bar{X}$	16.86	24.10	40.96
			s	6.94	8.04	
5	V_3-A_3	29	$\bar{X}$	15.28	20.03	35.31
			s	7.32	10.81	

trials; however, such conditions were included in Experiment III. Table 4.2 summarizes the relevant data from Experiment III on the four conditions. A comparison of Conditions A_2 and V_2 in Table 4.2 reveals that the scores for V_2 are better than the scores for A_2 grade by grade. An analysis of variance carried out on the nonmeaningful-verbal material and grades indicates that performance under the visual method of presentation is significantly better than under the auditory presentation. Thus, it seems that, across grades, nonsense syllables of the kind used here are learned slightly more efficiently when presented visually. Starting with the assumption that nonsense syllables should be easier to learn when presented visually in the fifth and sixth grades, a re-exam-

Table 4.2. Means and standard deviations of the number of correct responses, by conditions and grades.

Condition		Grade 4	5	6	10	12
A_2	$\overline{X}$	16.27	24.16	24.07	39.27	37.54
	s	9.91	12.91	12.45	14.94	14.06
	N	55	55	55	15	24
V_2	$\overline{X}$	23.53	25.56	30.29	41.22	44.04
	s	11.81	12.44	13.07	11.09	12.50
	N	55	55	55	59	28
A_3	$\overline{X}$	33.75	36.85	33.64	53.27	56.54
	s	14.35	13.92	15.40	8.31	6.56
	N	55	55	55	45	28
V_3	$\overline{X}$	34.98	38.00	43.91	48.80	53.96
	s	13.35	14.33	9.70	11.94	7.07
	N	55	55	55	50	23

ination of Table 4.1 reveals some small differences which follow this assumption. For the fifth grade, the subjects made an average of 8.8 correct responses during the first five trials when the material was presented auditorily while the other group made an average of 10.5 correct responses when the nonsense syllables were presented visually. During the last five trials when the method of presentation was changed, the first group made 15.9 correct responses on the average while the second group made 15.6. Even though the last two values are essentially equivalent, the former group made slightly greater improvement during the last five trials than did the latter group. Similar relationships exist for grade 6. The relationship for the meaningful-verbal material is less clear. An analysis of variance on the five grades from Experiment III for this material revealed that the difference between auditory and visual was not significant but that the interaction was. This statistic probably arises from the fact that the lowest three grades performed slightly better with the visual presentation while the upper two grades performed somewhat better with the auditory presentation.

The learning curves for the nonmeaningful-verbal conditions utilized in Experiment IV are presented in Figure 4.1. The curves for both the fifth and sixth grades show a drop between trials five and six when the shift is from visual to auditory at this point. The decrement in performance was analyzed by correlated "t" tests and found to be significant for both grades.

Figure 4.2 gives the learning curves for the meaningful-verbal material. The curve for A_3-V_3 shows a gradual improvement over the ten trials, but the curve for V_3-A_3 indicates little further improvement after the shift to auditory. However, the sample for V_3-A_3 had poorer performances throughout the task; if anything the difference between the two samples was increased by the shift from visual to auditory.

The following general conclusions emerged from the experiment:

1. There appeared to be no differential effect in the overall performance on a relatively simple paired-associate learning task which was related to whether the shift was from auditory to visual or visual to auditory.

2. There is some evidence that better performance on nonmeaningful-verbal material should occur when the presentation is visual than when it is auditory. Since the shift from visual to auditory showed a temporary decrement in performance when nonsense syllables were used, and since the overall performance was equal in these tasks in which the shifts were used, there is the possibility that the total performance was not as good as it would have been if the nonsense syllables had been presented visually throughout the task.

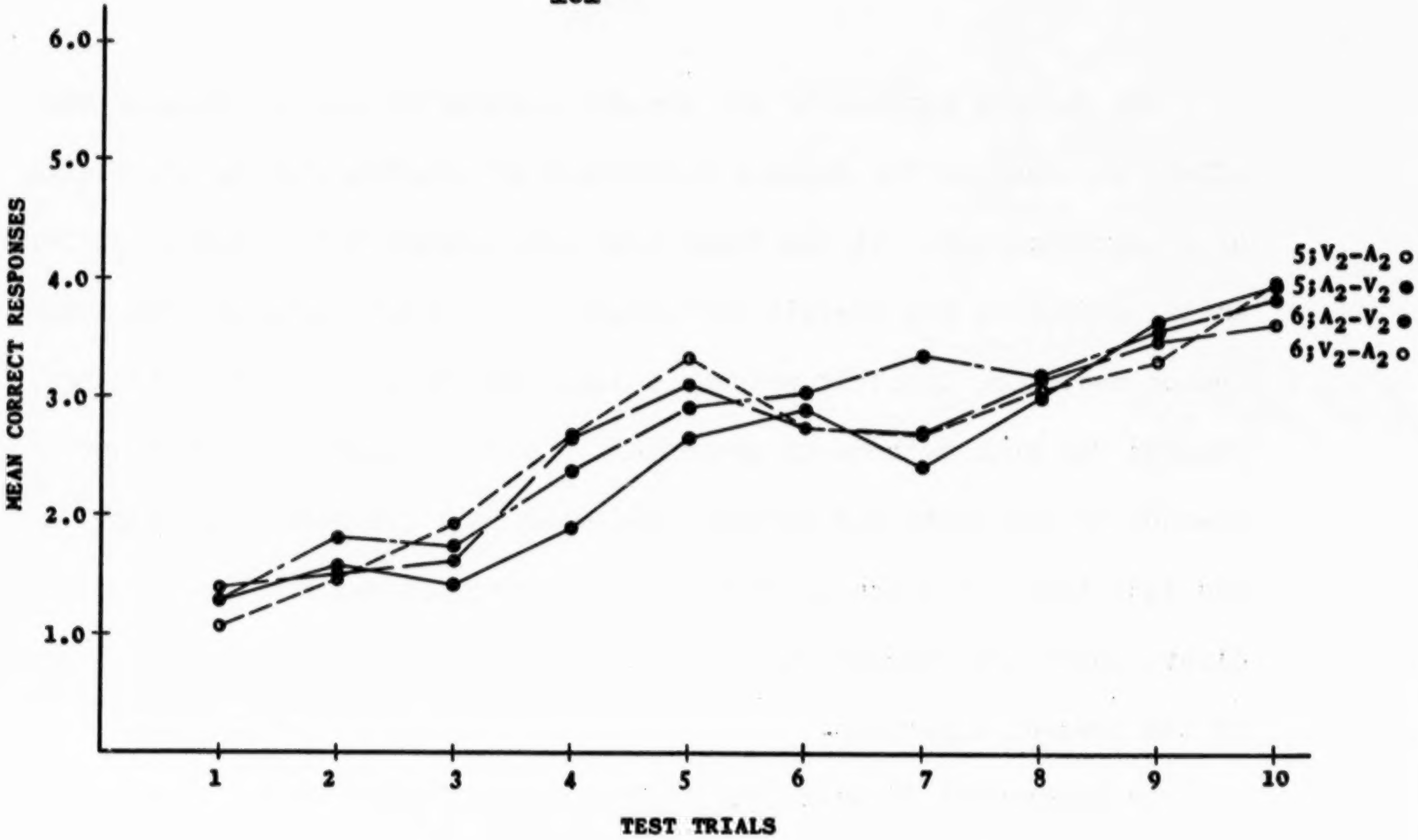
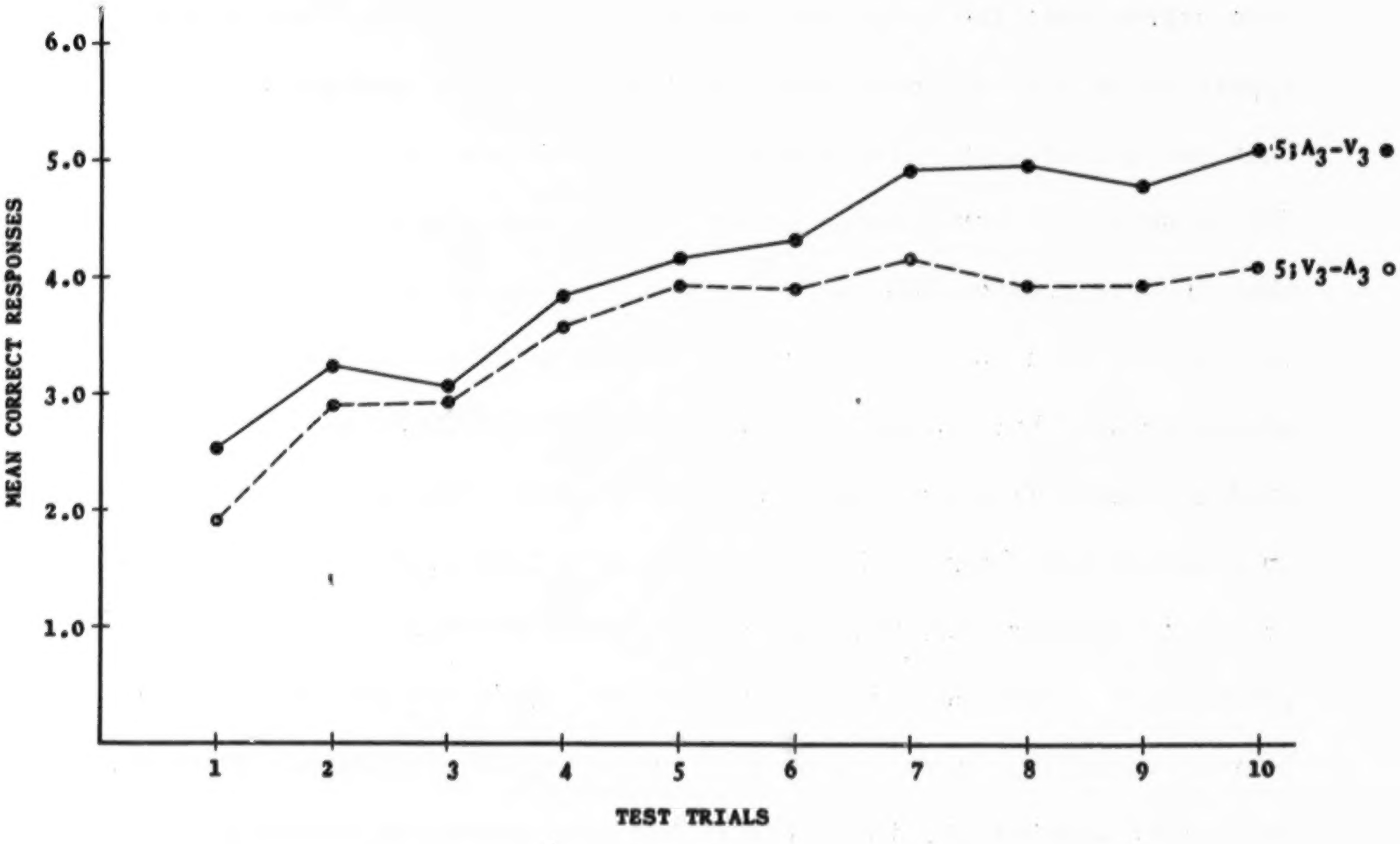


Fig. 4.1 Learning curves for nonmeaningful-verbal material when modality of presentation was shifted between trials 5 and 6.



The primary purpose of the present experiment was to evaluate the effect of changing the sensory modalities of presentation in the middle of a learning task. It was found that such change had no marked differential effect on the overall performance. It seems possible that some common mediator, implicit pronunciation, was involved in the learning process for both methods of presentation so that transition from one channel to the other was accomplished with relative ease. In spite of the fact that the evidence on which these conclusions are based appears clear, there are reasons for limiting this conclusion to the specifics of the present experiment.

In Experiment IV when the shift was from visual to auditory and the material was nonmeaningful-verbal, there was a momentary but significant drop in the learning curve. Since this same drop did not occur to the same degree when the shift was from auditory to visual, there would appear to be some evidence that the visual modality was preferred for that particular task. There was further evidence for this in Experiment III in which the performance scores for V_2 were significantly better than the performance scores for A_2 when considered across grades 4, 5, 6, 10, and 12. The superiority of the visual presentation was consistent across grades, but it was not always quantitatively equal. Other evidence comes from the first research project (Gaeth, 1960, p. 39), in which it was found that performance on a list learned auditorily was poorer if another list had just been learned visually than if the previous list had been learned auditorily. When the second list was learned visually, there was no difference in the performance which was auditorily. The observed differential in the shift from visual to auditory presentation was consistent across the five grades utilized in the earlier study.

While for practical purposes the auditory and visual methods of presentation of verbal material appear to be about equal in a paired-associate learning task, there are at least two variables which might produce deviations. First, it has been the opinion of the experimenters throughout the course of the present series of learning studies that it takes children slightly longer to catch on to the task when the presentation is pure auditory than when it is combined or visual. A second factor relates to the difficulty of the task. The decrement observed in the shift from visual to auditory in the present experiment occurred in connection with the nonsense syllables and not noticeably with the simple meaningful words. Although the earlier project used meaningful words, the list contained more items and was basically more difficult. Therefore, the character of the material and the point within the learning task in which the shift is made may both be contributing factors.

Experiment V

Learning in Kindergarten and First Grade; Six Conditions

ABSTRACT. Small groups of kindergarten and first grade subjects were tested under four visual and two auditory conditions which varied in degree of meaningfulness and verbalness. A difference in performance due to grade was obtained with first grade better than kindergarten. Learning was found to be a function of meaningfulness rather than modality. Both findings are consistent with conclusions drawn from higher grades and more complex conditions.

A. Introduction

Part of the plan of the present investigation was to study learning in children across the total grade range. The particular set of conditions used was suggested by the findings in Experiment IV that unfamiliar verbal material (nonsense syllables) seemed to be learned better when presented visually than when the auditory presentation was employed. The subjects from whom these results were obtained were all able to read since grades 4 and above were used. This experiment was designed to evaluate the relationship between meaningfulness and modality with subjects who were unable to read.

A generally held assumption is that children are basically auditory until they learn to read, after which they tend to utilize the visual modality more efficiently for learning. From this point of view, it would be expected that children would perform better on auditory conditions than on comparable visual conditions if they are still unable to read. In order to test this hypothesis, pictures of common objects were used for the visual condition while the names of the objects were used in the auditory condition.

A second hypothesis tested in this experiment was that performance on visual nonsense syllables and visual meaningful words would not differ significantly. To the non-reader, both of these stimuli should appear to be equally nonmeaningful groups of letters.

The third hypothesis advanced was that first-grade students should show a higher overall performance level than pupils in kindergarten. This was expected for several reasons, the major one being that the orientation to learning situations should be improved as a result of the kindergarten experience. Also, the first graders would have a greater acquaintance with the letters of the alphabet, although still non-readers, and should be able to discriminate better among them.

In summary then, this experiment was designed specifically to test three hypotheses:

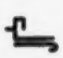
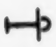
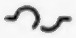
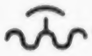
1. Performance on auditory conditions would be better than on comparable visual conditions.
2. Performance on visual nonsense syllables would be equal to that on visual words since these subjects are non-readers.
3. First-grade pupils would perform at a higher level than would pupils in kindergarten.

B. Experimental Procedures

Four visual and two auditory conditions were used in the experiment. Stimuli and responses were selected from the lists used with older subjects. All lists were shortened to four items and the manner of obtaining responses from the subjects was necessarily modified. Three random orders of presentation were used.

The conditions used are described in Table 5.1. As seen there, all the conditions were similar in content to conditions used in other experiments of the project. The only new dimension was V3p which used meaningful pictures for stimuli. As in previous experiments, an alternating learning and test trial procedure was used for a total of ten test trials.

Table 5.1. S-R pairings for the six conditions.

Modality	Condition	S-R Pairs			
Auditory	A_2	DAQ - L,	KEZ - M,	WUB - H,	JID - V
	A_3	GUN - L,	BOY - M,	CAT - H,	ARM - V
Visual	V_1	 - L,	 - M,	 - H,	 - V
	V_2	DAQ - L,	KEZ - M,	WUB - H,	JID - V
	V_3	GUN - L,	BOY - M,	CAT - H,	ARM - V
	V_{3P}	(Same as V_3 but pictures used for stimuli)			

Each subject received a set of four cards on which the response letters were printed in the same type as used on the slides. During the preliminary instructions, a set of cards was held up and the subjects were requested to point to the card on their desks which looked the same. This was repeated several times until the subjects could perform this identification readily. No attempt was made to teach the names of the response letters to the subjects. However, in the auditory conditions the response letter was both said and shown by the experimenter during the learning trials.

Following this practice in discriminating the responses, the task was explained to the subjects, and they were instructed to use the same procedure of pointing to the responses during the test trials. A "semi-individual" testing procedure was employed. Since the subjects were instructed to point to the response, recording of these choices had to be made. Personnel from the project functioned as recorders; each recorder sat between two subjects and noted their responses. Several staff members were available at one time so that it was possible to test six or eight subjects at one time.

The pacing of the presentation of stimuli was geared to the speed with which the subjects responded, as indicated by the recorders. The slide projector was manually operated for the visual conditions; auditory conditions were given orally by the experimenter who sat facing the subjects. In this way, they could see the responses as well as hear them. The combined presentation of the responses was utilized to avoid possible complications resulting from the subjects' unfamiliarity with the name of the letters.

C. Results and Discussion

The mean number of correct responses, sample sizes, and the standard deviations for ten trials are presented in Table 5.2 for the two grades on the six experimental conditions. Figure 5.1 presents the data graphically.

An analysis of variance was made of these data; the results are given in Table 5.3. As shown there, both main effects (grade and condition) were significant. The grade effect shows that the first grade

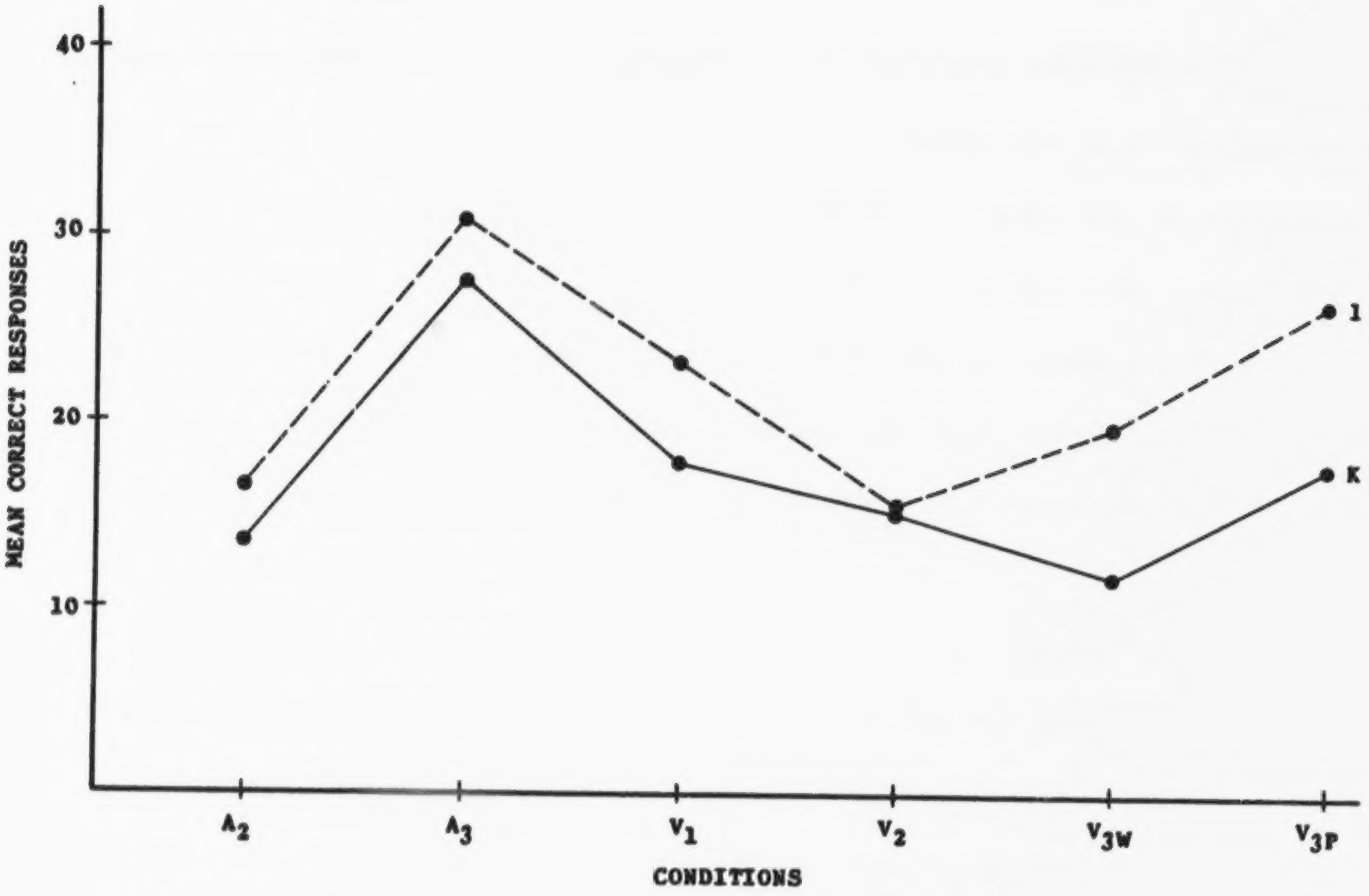


Fig. 5.1 Mean correct responses for six conditions, kindergarten and grade 1.

Table 5.2. Means and standard deviations of the number of correct responses, by conditions and grades.

Grade		Condition					
		A_2	A_3	V_1	V_2	V_3	V_{3P}
K	$\overline{X}$	13.5	27.8	17.9	15.1	11.8	17.8
	s	4.1	8.9	9.3	5.3	6.7	7.4
	N	10	12	14	16	14	16
1	$\overline{X}$	16.6	30.9	23.2	15.6	19.8	26.4
	s	5.9	7.5	11.2	7.6	8.1	9.0
	N	10	12	12	12	10	10

achieved significantly higher scores than the kindergarten across conditions, supporting the hypothesis. Differences between grades for each condition were evaluated using a t-test. The only significant differences ($p < .02$) were in the two visual meaningful lists (V_3 and V_{3P}), although in no condition did the mean performance of the kindergarten exceed that of the first grade.

Table 5.3. Summary of the analysis of variance and of the Scheffe tests for six conditions and two grades.

Source	df	MS	F
Conditions (C)	5	744.91	12.31**
Grades (G)	1	827.04	13.66**
C x G	5	59.11	.98
Within Cell	136	60.53	

$\overline{X}$	15.1	15.1	15.3	20.3	21.1	29.3
Conditions#	A_2	V_3	V_2	V_1	V_{3P}	A_3

**p < .01. #Lines connect nonsignificant differences at p = .05.

The Scheffe procedure was used to compare the main effects of the various conditions. The results of these tests, presented in Table 5.3, indicate that performance is significantly better with auditory meaningful words than with any other condition. The hypothesis that children who are non-readers are auditory in modality preference is supported to some extent by these findings. As discussed previously, the conditions A_3 and V_3p may be viewed as comparable in content. The fact that A_3 is significantly higher in mean performance than V_3p supports the above hypothesis. However, the findings concerning A_2 and V_2 conflict with this evidence. Thus, it would seem that the original hypothesis should be restricted to meaningful material since no significant difference between modalities was found with nonsense syllables.

The third hypothesis tested in this experiment, that no difference in performance should be obtained between V_2 and V_3 is also supported by these data. Table 5.3 shows that the slight difference between these means is not significant.

One final step in the analysis of these data was to determine whether the performance differed from that which would be obtained through chance. Since there were four possible responses that could be made to each of the four stimuli and since the four stimuli were all presented ten times, chance was defined as one-fourth of forty or a score of ten for the ten test trials. All of the mean scores reported in Table 5.2 except that of the kindergarten on V_3 ($\overline{X} = 11.8$) were significantly higher than chance ($p < .05$), suggesting that learning did occur in all cases except that one.

D. Summary and Conclusions

The results of this experiment were:

1. First-grade subjects performed significantly better than those in kindergarten on conditions using visual meaningful words and pictures; overall, their performance exceeded that of kindergarten on all conditions.
2. Auditory meaningful words were learned significantly better than any of the other five conditions.
3. Auditory presentation of nonsense syllables did not facilitate learning when compared with visual presentation; performance on these two conditions was not significantly different.
4. No significant difference was found in performance between visual nonsense syllables and visual meaningful words.
5. All performances except one were significantly different from chance, the exception being the kindergarten group with visual meaningful words.

Of the three hypotheses which this experiment tested, two were clearly supported and the other was given qualified support. The first-grade pupils performed significantly better than those in kindergarten; verbal material presented visually was learned equally as well (or as poorly) whether the stimuli were nonsense syllables or meaningful words. Since these subjects were not able to read, they were apparently discriminating between the items only on the basis of the visual cues provided by the letters in the stimuli.

The hypothesis that non-readers would perform better on auditory conditions than on those employing the visual modality had to be qualified. On the basis of the evidence obtained here, it appears that this assumption is valid only when meaningful material is involved. When strange or nonsense material is being presented, the auditory modality is not more efficient than the visual. In fact, the visual presentation was learned slightly better, although not significantly so, even though these subjects were unable to read. It would seem that the visual presentation of nonmeaningful-verbal material provides as many cues for discrimination and learning as does the auditory.

When these findings concerning the nonsense syllables are compared with the results using similar material with subjects who are able to read (Experiment IV), there is greater consistency than contrast between readers and non-readers concerning the efficiency of the two modalities in rate of learning new or strange material. Both readers and non-readers indicated that the task involving nonsense syllables was as easy or easier to learn visually as auditorily. With the reading group, the assumption was made that implicit pronunciation of the visual stimuli may have contributed to the superiority of that modality by creating a subjective combined condition. However, it can be presumed that the non-readers were not employing a pronounceable unit as a verbal mediator in the visual condition, and yet they performed as well on this condition as on the auditory where the pronounceable unit was given. Certainly this finding deserves further investigation.

Experiment VI

Pre-School Children; Three Conditions

ABSTRACT. Small samples of nursery school children were tested under three auditory conditions representing two levels of meaningfulness. It was found that, with modifications in procedure, these children could perform on a paired-associate learning task. When performance was compared with that of kindergarten and first grade, these subjects performed about equally as well with nonsense syllables but significantly poorer with meaningful words.

A. Introduction

It had been assumed that it might be necessary to utilize very young children in order to get a satisfactory understanding of the audio-visual reception of material to be learned. Experiment VI was a pilot study with young children and was designed to investigate the effects of the nature of the stimulus material on a paired-associate learning task with children in the age range of 3 to 5 years. Three lists of verbal material were prepared as stimuli; viz., nonsense syllables, nouns representing familiar objects, and words that might function either as nouns or verbs.

Sculptured wooden figures of persons and animals were used as response items. These figures were somewhat stylized but easily identifiable as a woman or mother, a boy, a girl, a dog, and a cat. They were proportional to each other in size, ranging from 6" in height for the mother to 1 1/2" for the cat.

Since the experiment was exploratory, no formal hypotheses were advanced. However, it was expected that performance would be better on meaningful words than on nonsense syllables and that performance at this age level would be less than that of kindergarten and first-grade children.

B. Experimental Procedures

As indicated above, three lists of paired associates were prepared for the study. The nonsense syllables were the same as those used with kindergarten and first grade. This condition is referred to as A_2, consistent with previous notation. A new list of meaningful words was prepared. In the old list there were obvious similarities of stimulus words "boy" and "arm" to the new response items, boy, girl, etc. The new stimulus words were nouns common to five vocabulary lists reported by Burroughs (1957). The condition using meaningful words is identified as A_3. A third condition of meaningful words was presented to another group of subjects. This condition, identified as A'_3, used meaningful words common to the five children's vocabulary studies which have usage both as a noun and as a verb; e.g., help. Table 6.1 shows the S-R pairings for these conditions. All stimuli were spoken, and all responses were made by pointing to a wooden figure. The figure "cat" was substituted for the figure "boy" in Conditions A_3 and A'_3. The reason for the substitution was that the S-R pair "kez-dog" in Condition A_2 was learned

Table 6.1. S-R pairings for the three conditions.

Condition		
A_2 S R	A_3 S R	A'_3 S R
wub - mother	sun - mother	help - mother
daq - boy	house - cat	turn - cat
jid - girl	book - girl	watch - girl
kez - dog	table - dog	name - dog

about twice as often as any other single pair. This apparently was a result of response distinctiveness. When the figure "cat" was added to the response items, no one S-R pair was learned excessively better than any other.

The subjects were 27 children, 14 boys and 13 girls, ranging in age from 3 years, 2 months to 5 years, 3 months. Mean age was exactly 4 years. The children were half-day students at the nursery school operated by the College of Education, Wayne State University. This school serves as a training ground for prospective teachers, and one of its objectives is to provide experience with children from all socio-economic backgrounds. For this reason, the sample probably was not as biased as might be expected in a private nursery school.

Only small samples were used in each condition because the population available at the nursery school was limited and because the experiment was of an exploratory nature.

Each subject was tested individually. Consistent with the other experiments, alternate learning and test trials were employed for a total of ten test trials. The same orders of presentation were used as in Experiment V. During the learning trials, the experimenter would say the stimulus item and then hold up the correct response figure. During test trials, the stimulus was given again orally by the experimenter, and the child was asked to point to the response figure. This response was then recorded by the experimenter. All phases of the procedure were paced to the child's needs.

Recall data were also obtained for these subjects. From one to three days after the subject was tested, the experimenter again gave the stimulus items orally and recorded the recall responses precisely as in the original test trials.

C. Results and Discussion

The mean performances of the subjects in the three experimental conditions are presented in Table 6.2 along with the sample size and standard deviations.

Table 6.2. Means and standard deviations of the number of correct responses by conditions.

	Conditions		
	A_2	A_3	A'_3
$\bar{X}$	16.38	20.70	22.00
s	7.19	8.59	9.01
N	8	10	9

A simple analysis of variance of the performance on the three conditions showed that the means did not differ significantly from one another. The summary table of this analysis is given in Table 6.3.

Table 6.3. Summary of the simple analysis of variance of the three conditions.

Source	df	MS	F
Conditions	2	74.91	1.06
Within	24	70.95	
Total	26		

Thus, the expectation that performance would be better on the meaningful word lists than on nonsense syllables was not supported statistically. Examination of the means for the conditions in Table 6.2 shows that the trend is in the expected direction. The fact that the differences were not statistically significant probably reflects the small sample sizes involved and possibly the fact that the response items became more difficult when "cat" was substituted for "boy" for Conditions A_3 and A'_3.

The mean recall scores were 2.2, 1.9, and 2.4 for the four items on the A_2, A_3, and A'_3 lists respectively. The scores are not considered remarkable except that the children recalled proportionately more of the associations under Condition A_2. These findings probably reflect the nature of the material and may be viewed as consistent with the definition of meaningfulness used in this project. The stimuli for A_3 and A'_3 are meaningful words and elicit many more associations in contrast to the nonsense syllables of A_2. Thus, on recall, A_2 would be expected to show greater retention in comparison to the original learning since the only associations available for these stimuli were the learned responses.

Since the stimuli in Condition A_2 were the same as those used with children in kindergarten and first grade, a simple analysis of variance was done for this condition across the three groups. The mean performance for kindergarten on A_2 was 13.50 (N = 10), for the first grade 16.60 (N = 10), while the nursery school subjects had a mean of 16.38 (N = 8). These differences were not expected to be significant and, as shown in Table 6.4, the analysis supported the conclusion.

Although the stimuli in A_3 were changed, they remained four one-syllable meaningful nouns having no obvious similarity to response items.

Table 6.4. Summary of the simple analysis of variance of groups for Condition A_2.

Source	df	MS	F
Groups	2	29.05	.87
Within	25	33.23	
Total	27		

A comparable simple analysis for A_3 was considered justified for this reason. The mean for kindergarten was 27.75 (N = 12), for first grade, the mean was 30.92 (N = 12), while for nursery school the mean was 20.70 (N = 10). Table 6.5 indicates that the differences among grades were significant. By examination of the means, it is evident that the nursery school performed at a much lower level than did the other two groups which were found not to differ significantly in Experiment V. Interpretation of this finding is complicated by the fact that different stimuli and responses were used for the nursery school subjects.

Table 6.5. Summary of the simple analysis of variance of groups for Condition A_3.

Source	df	MS	F
Groups	2	293.15	4.24*
Within	31	69.14	
Total	33		

*$p < .05$.

D. Summary and Conclusions

The major findings of this study were:

1. There were no significant differences in the performances among the three auditory paired-associate learning tasks for these pre-school subjects, although the progression of the means suggests that nonsense syllables may be learned more slowly than meaningful words.

2. Pre-school subjects do not differ significantly from either kindergarten or first grade subjects in the auditory learning of nonsense syllables as studied here.

3. With meaningful words, the kindergarten and first grade pupils both performed significantly better than pre-school children although this finding may be confounded with stimuli and/or responses since both were changed for this study.

4. Retention scores of nonsense syllables with pre-school subjects were relatively better than with meaningful words.

At the beginning of the present project, it was thought that it might be necessary to utilize pre-school children in order to gain the necessary understanding of the manner in which older children use audition and vision in learning tasks. While the data on pre-school children are no longer so urgent to the present project, it was of interest to determine experimentally whether children between the ages of 3 and 5 years could and would perform on paired-associate tasks. If so, it would be possible to relate their performances meaningfully to older children. The present experiment demonstrates, with certain small modifications in design, that such data can be gathered. A similar pilot study was started in which a temporary piece of apparatus was developed for the presentation of the stimuli. Specifically, the visual stimuli were mounted on a wooden disk which could be rotated by the experimenter so that the desired item appeared in a viewing window. The response items were available to the child just above a telegraph key associated with the item. The child responded by closing the appropriate key. The apparatus was arranged so that pushing the correct key revealed the picture of a series of comic characters, while pushing the wrong key resulted in no reinforcement. This apparatus was used with several subjects and appeared to be yielding reasonably valid data. However, pre-vacation activities at the nursery school prevented the accumulation of scores on a satisfactory number of subjects.

Both the pilot study reported here and the one described only briefly indicate that little difficulty would be encountered in gathering paired-associate data on very young children using auditory, visual, or audio-visual methods of presentation. The one modification that seems necessary would be the use of multiple-choice response items.

While the data gathered in connection with Experiment VI are of minor importance in the total project, the fact that recall of the correct response item appears to be better for nonsense syllables than for meaningful words is interesting. Defining meaningfulness in terms of the number of associations, the data here would suggest that recall in A_3 and A'_3 is interfered with by the intrusion of competing associations. The nonsense syllables, on the other hand, had no competing associations and recall was facilitated by this. It might be said that, through learning, the nonsense syllables each acquired only one meaning, the particular responses associated with them.

Experiment VII

Learning in a School for the Deaf; Three Visual Conditions

ABSTRACT. Three visual conditions were administered in three orders to hearing-handicapped subjects representing three reading levels. The "high" reading level group performed consistently better throughout. Compared with normal-hearing subjects, the deaf performed as well as or better than normal subjects of comparable reading levels.

A. Introduction

Earlier research (Graunke, 1959; Gaeth, 1960) has shown that hard-of-hearing and deaf subjects performed as well as normal subjects on paired-associate learning tasks when the material was presented visually and was also meaningful. The purpose of the present experiment was to determine if the performances of deaf children would also be equal to the performances of normal-hearing children when the material was nonverbal and nonmeaningful.[1]

The study was designed to take into account two variables in addition to three types of visual material. First, it was assumed the reading level in a school for the deaf was the nearest equivalent to grade placement in a public school. If so, reading level would be expected to be related to the learning scores, perhaps especially with the meaningful-verbal material. Therefore, it was planned to subdivide the subjects on the basis of reading levels. Second, experience had shown that it is more difficult for the experimenters to explain an unusual task to children in a school for the deaf than it is to normal children. Therefore, it was assumed that the effect of learning-the-task would be greater for these children and would appear as an order effect. By administering all three visual tasks to all subjects, in different orders, it would be possible to evaluate this effect. Two main hypotheses were tested by this experiment:

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[1] The subjects in Experiment VII were all from a school for the deaf. Even though most of them had residual hearing, they are simply referred to as "deaf" for convenience in reporting.

1. Deaf subjects would perform as well as hearing subjects at the same reading level on all three visual conditions.

2. Practice would facilitate learning independent of the order in which the conditions were presented.

B. Experimental Procedures

Students at a residential school for the deaf were selected as subjects for the experiment. On the basis of reading achievement on the Paragraph Meaning score of the Stanford Achievement Test and the availability of subjects, three categories of reading levels were established. The "low" category comprised the grade equivalent of 2.6 through 3.4, the "medium" included 3.5 through 4.4, and the "high" group was made up of children with a reading level of 4.5 or above. The mean reading levels for the three groups were 2.93, 3.90, and 6.24, respectively.

Twelve subjects from each reading level were obtained and were assigned to three experimental groups in such a way that each reading level was equally represented. Specifically, each experimental group consisted of twelve subjects, four from each reading-level category. The averaged reading levels for the three groups were approximately equal; i.e., 4.45, 4.28, and 4.34. Each experimental group was given all three visual conditions in a different order. The order for Group I was V_1, V_2, and V_3; for Group II, it was V_2, V_3, V_1; and for Group III V_3, V_1, V_2. In all instances, the conditions were administered on successive days.

The subjects ranged in age from 11 to 18 years with a mean age of 14.28. A combination of oral, written, and gesture techniques were used to explain the tasks to the subjects. Otherwise, standard procedures were followed so that the performance of the deaf subjects could be compared with that of the normal subjects.

C. Results

Table 7.1 presents the mean number of correct responses for each reading level, each condition, and each experimental group as well as certain summarizing values. The diagonal from upper left to lower right represents the initial conditions for the respective groups. The effect of reading level can be seen in the column of means. For each condition there is a perfect rank relationship between reading level and performance score; however, the differences between the medium and low level groups are not great. The overall means for the reading levels were 40.45, 41.94, and 49.50 from lowest to highest, respectively. The expected order effect appeared in that the total mean for the first day was 38.78, the second day it was 45.97, and for the third day it was 47.47. An inspection of the table reveals that the most deviant scores occurred for Group II under Condition V_2. These scores suggest that the learning task was most difficult when the nonsense syllables were presented initially and also suggest the possibility of a significant interaction between conditions and order.

Table 7.1. Mean correct responses for deaf subjects on the three visual conditions, by reading levels.

Condition	Reading Level	Experimental Group			
		I	II	III	Total $\bar{X}$
V_1	High	52.00	50.00	55.50	52.50
	Medium	49.50	43.75	45.75	46.33
	Low	53.00	28.25	46.00	42.42
	$\bar{X}$ - V_1	51.50	40.67	49.08	47.08
V_2	High	41.25	32.25	51.75	41.75
	Medium	37.50	16.50	44.75	32.92
	Low	47.00	6.50	40.75	31.42
	$\bar{X}$ - V_2	41.92	18.42	45.75	35.36
V_3	High	55.00	54.50	53.25	54.25
	Medium	56.25	45.75	40.75	47.58
	Low	56.75	40.50	45.25	47.50
	$\bar{X}$ - V_3	56.00	46.92	46.42	49.78
	Total $\bar{X}$	49.81	35.34	47.08	

A "Type III" analysis of variance (Lindquist, 1953) was done; the summary results appear in Table 7.2. All three main effects; i.e., order, reading level, and conditions, were significant, as well as the interaction between conditions and order. The interaction between conditions and reading level was not significant.

The significance of the differences between individual pairs of mean scores by reading level was evaluated by the t-test (Lindquist, 1953). The means by reading levels were 49.50, 41.94, and 40.45 from high to low, respectively. The learning curves for the three reading levels are presented in Figure 7.1. The t-test revealed that the "high" reading

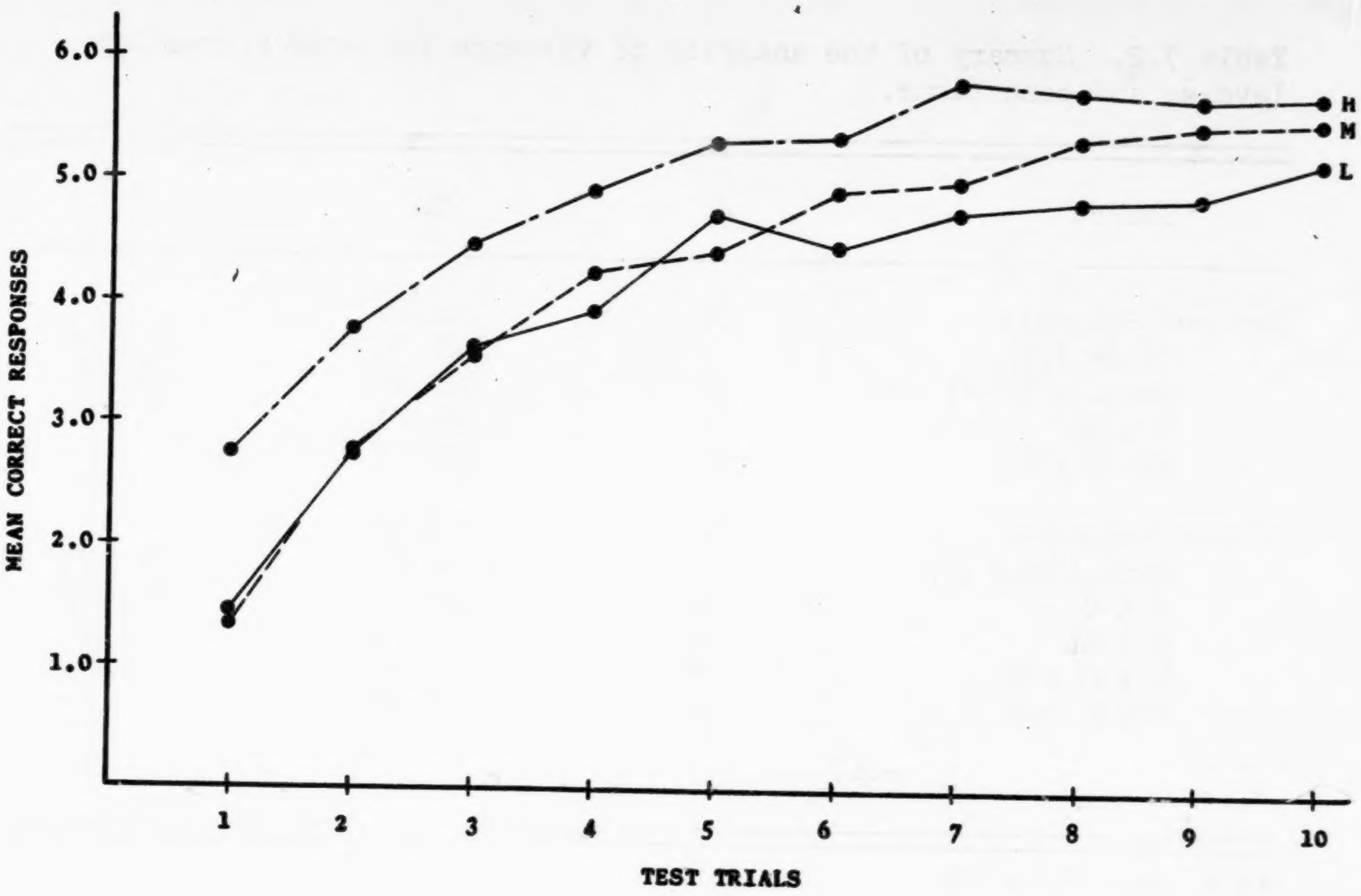

Fig. 7.1 Learning curves for Conditions V_1, V_2, & V_3; by reading levels of deaf subjects.

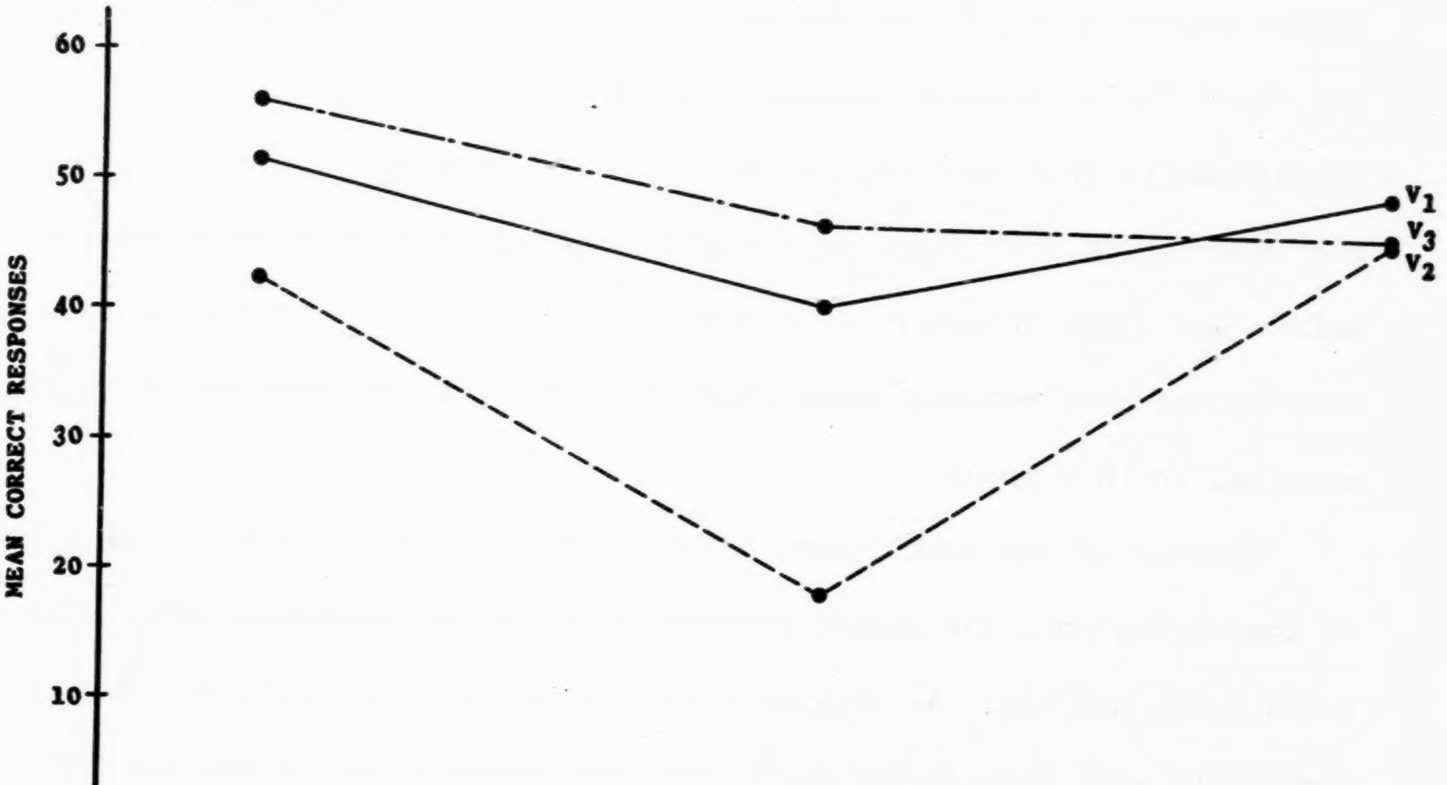

Fig. 7.2 Mean correct responses for the three visual conditions presented to three groups in different orders.

Table 7.2. Summary of the analysis of variance for orders, reading levels, and conditions.

Source	df	MS	F
Between Subjects	35	342.46	
Order (O)	2	2129.51	13.25**
Reading Level (RL)	2	825.15	5.13*
C x RL	4	434.23	2.70
error (b)	27	160.73	
Within Subjects	72	143.49	
Conditions (C)	2	2115.07	35.32**
C x O	4	617.94	10.32**
C x RL	4	19.54	.33
C x O x RL	8	39.70	.66
error (w)	54	59.88	
Total	107		

*$p < .05$; **$p < .01$

level category (mean reading level was 6.24) obtained significantly higher scores ($p < .01$) on the tasks than either the "medium" (3.90) or the "low" (2.93) reading levels, while the latter two did not differ significantly from each other. This finding is in general keeping with the observation that there is a significant difference among grades no matter what type of material is being learned, but is contrary to the speculation that reading level would only benefit the learning of verbal material in this group.

Because of the significant interaction between conditions and order of administration, the simple effects of these two variables were calculated independently. As suggested by Figure 7.2, the differences among conditions were significant ($p < .01$) for Groups I and II but not for Group III. Further analyses showed that V_2 was significantly poorer than V_1 and V_3 for Group I but that the V_1 and V_3 did not differ significantly from each other. For Group II all three conditions differed significantly. Probably the most important difference among the data presented for the three groups in Figure 7.2 is the order in which the conditions were presented. For Group I, the order was V_1, V_2, V_3; for Group II, it was V_2, V_3, V_1; and for Group III, it was V_3, V_1, V_2. The conclusion drawn in Experiment III that the V_2 material was more difficult than the V_1 material is borne out by these results in general. However, the most dramatic difference occurs in Group II where the V_2 condition was presented first. Apparently this condition provides less information concerning the task itself when presented initially since Group II performed disproportionately poorer on this condition than on V_1 or V_3. Assuming that order of presentation and, thereby, learning the task itself is a major factor, it is interesting that in Group III, Conditions V_3 and V_2 show almost identical mean correct responses. It is not possible to go beyond speculation in these results since none of the experiments utilizing subjects with normal hearing involved repeat measurements and since only Group II had V_2 as an initial task.

Table 7.3 presents the mean correct responses for the initial performance and for the average of the three groups of the deaf subjects and for grades 4, 5, 6, 10, and 12 of the normal subjects on the three conditions. Although both the initial performance and the mean overall performances are presented for the deaf subjects, only V_2 displays a marked discrepancy in these two measures. As mentioned in the Experimental Procedures, the three groups of deaf subjects had mean reading levels of 4.45, 4.28, and 4.34 respectively. In this respect, they

Table 7.3. Mean correct responses for the deaf group and five normal groups on the three visual conditions.

	Deaf#		Grade				
Condition	$\bar{X}_1$	$\bar{X}_t$	4	5	6	10	12
V_1	51.50	47.08	19.84	34.93	32.82	43.39	47.04
V_2	18.42	35.36	23.53	25.56	30.29	41.22	44.04
V_3	46.42	49.78	34.98	38.00	43.91	48.80	53.96

# $\bar{X}_1$ represents the mean scores for the group that was tested initially on each condition.
$\bar{X}_t$ represents the total mean for the three groups.

were probably most comparable to the normal fourth-grader.

The hypothesis that deaf subjects would perform as well as or better than normal subjects at the same grade level is supported by these data. Of particular interest is the fact that the rank-order position of the deaf subjects varies greatly according to the condition considered. They performed better than the twelfth-graders with Condition V_1 whether the initial or the repeat measures score is considered. With V_2 the initial performance of the deaf is below that of the fourth grade, but when all scores are counted, the mean falls between grades 6 and 10. With Condition V_3 the performances for the deaf are about equal to that of tenth-graders.

D. Summary and Discussion

The results of Experiment VII may be summarized as follows:

1. The subjects from the schools for the deaf performed as well or better than normal-hearing subjects of comparable reading levels on all three visual tasks.

2. Practice in the task did not result in consistent improvement in performance independent of the material which was presented.

The results again show the students in a school for the deaf to be equal to their normal-hearing counterparts when learning a simple paired-associate task that is presented visually. Actually, they scored unexpectedly high on the nonmeaningful symbols. This would seem to support a position that hearing-handicapped subjects perform best on material that is concrete and visual. On the meaningful-verbal material, their performance ranks them at about the tenth grade, which is also better than would be predicted. Only on the nonmeaningful-verbal material do they rank low and then only when the performance on the initial condition is considered. Re-examination of Table 7.1 reveals that Group II performed considerably poorer on Condition V_2 than did Groups I or III. In the absence of corroborating evidence, it is considered inappropriate to assume that the deaf subjects are below the normal subjects of comparable grade placement even on nonmeaningful-verbal material.

Even though the hypothesis that practice would facilitate learning independent of the order in which the conditions were presented had to be rejected for lack of statistical evidence, there was a trend suggesting that practice did have some effect. When all the data collected on the first day were combined, the mean score was 38.78, the second day the mean was 45.97, and the third day, 47.47. It is likely that a study could be designed which would prove this hypothesis; however, the type of material utilized is considered to be a more important variable.

Experiment VIII

Learning in the Fourth Grade and in Schools for the Deaf; Six Conditions

ABSTRACT. Four audio-visual conditions were presented for ten trials followed by five additional trials using the auditory component only. Two auditory conditions were presented for fifteen trials as a control. Results indicated that the hearing subjects attended to the more meaningful component while the subjects from the schools for the deaf tended to learn the visual material in a bimodal presentation. However, the two groups performed about equally as well on nonmeaningful-nonverbal auditory material.

A. Introduction

Previous research supported the inference that the child tends to respond to paired-associate material either visually or auditorily but not bimodally. One of the objectives of the present project was to gain additional evidence relevant to this hypothesis. The "eleventh trial" data from the combined conditions, discussed in Experiment III, indicated that the subjects attended chiefly to the channel which presented the more meaningful material. These data suggest that unimodal attention may be the rule, especially with younger children, but that the modality preference is influenced by the degree of meaningfulness of the material.

Experiment VIII was designed primarily as a further exploration of the efficiency of bimodal presentations for groups of children with severe hearing losses.[1] In straight combined conditions, where the same material is presented visually and auditorily, these subjects have shown no benefits from bimodal presentation over a simple visual presentation when learning paired-associate material. However, this can hardly be considered abnormal since subjects with normal hearing perform similarly. The difference, of course, lies in the fact that the subjects with normal hearing also perform about equally as well with an auditory presentation. Our previous research has indicated that all hearing-handicapped children, even those with mild hearing losses, perform more poorly with an auditory presentation. Part of the unexpected difference in performance has been thought to be related to an increased difficulty in learning to learn the task, but most of the difference would seem to be related to the ability to use the auditory sensory channel on these stimuli.

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[1] As noted in connection with Experiment VII, the hearing-handicapped subjects all came from schools for the deaf. For convenience in reporting, they are usually referred to as deaf subjects or deaf children.

In Experiment III it was shown that children with normal hearing tend to utilize the modality in which the more meaningful material is being presented when there is a mixing of the level of meaningfulness between the visual and auditory presentations. In other words, the experimenter can, at least partially, control the sensory channel which the subject utilizes by manipulating meaningfulness. Experiment VIII was designed to determine the degree to which children with severe hearing losses could be forced to utilize the auditory stimuli and to estimate the potential of the auditory reception mechanism.

The procedure for presenting the paired-associate material was modified slightly to carry out the experiment. Four combined conditions were selected in which the level of meaningfulness was either low or was mixed between the sensory channels. Each of these four combined conditions was presented for a total of ten trials as has been the standard procedure. However, upon completion of the tenth trial, an additional five trials were presented in which only the auditory component of the material presented during the first ten trials was given. It was assumed that the learning curve at the transition between the combined presentations and the straight auditory presentation would be an indication of the degree to which the auditory component had been attended to during the combined presentations. It was assumed further that the subjects would be fully familiar with the task by the end of the tenth trial, and, therefore, the last five trials would give some indication of the ultimate potential of the subjects to use the auditory material. In order to determine whether the combined presentation over ten trials facilitated the learning of the auditory component during the last five trials, two control conditions were introduced in which the auditory material was presented alone for a total of fifteen trials. Since these exact procedures had not been used with normal-hearing children, the six modified conditions were presented to six independent groups of fourth-grade children as well as to the children with severe hearing losses.

The experiment was designed to test the following hypotheses:

1. The performance of the normal-hearing children on the last five trials, auditory alone, would be related primárily to the meaningfulness carried by the auditory channel.

2. In view of the strong preference for the visual modality among children with severe hearing losses, it was predicted that modality rather than meaningfulness would be the more important variable.

3. Since even normal children seem to attend to a unimodal aspect of a combined stimulus, it was predicted that the combined presentation over the first ten trials would not improve the amount learned during the last five trials when compared to the last five trials of a straight auditory condition.

B. Experimental Procedures

Four combined conditions were selected; viz., A_1V_1, A_3V_1, A_1V_2, A_3V_2. Each of these conditions was administered according to the standard paired-associate learning procedure for a total of nine test trials. A short rest was allowed before presenting the tenth learning and test trials. Then, without interruption, the auditory component was presented in the standard manner for an additional five test trials. The rest period was given the subjects after the ninth test trial to offset fatigue effects. Two control conditions, A_1 and A_3, were also administered for fifteen trials with the same rest period after the ninth trial.

The six conditions as used for this experiment were:

(1) A_1V_1-A_1 (4) A_3V_2-A_3
(2) A_3V_1-A_3 (5) A_1-A_1
(3) A_1V_2-A_1 (6) A_3-A_3

The symbols have the standard meaning; the hyphen and the final symbol indicate the presentation for the eleventh through fifteenth trials. Each condition was administered to an independent group of fourth-grade subjects from public schools and to groups of hearing-handicapped subjects from two residential schools for the deaf. Attempts to collect valid data from the subjects from the schools for the deaf on A_3 failed because the subjects were unable to discriminate the words being presented.

The hearing levels for the deaf subjects were not assessed by the experimenters; instead, the appropriate information was abstracted from each child's records. Table 8.1 gives the averaged hearing losses for the 250-500 cps and the 1000-2000 cps ranges in dB re normal by the conditions in which the children were used. It is clear from Table 8.1 that these subjects had severe hearing losses.

Table 8.1. Mean hearing levels for 250-500 and 1000-2000 cps in dB re normal and mean reading level by test conditions.

		Mean dB Loss		
Condition	N	250-500 cps	1000-2000 cps	Reading Level
A_1V_1-A_1	16	69.88	90.69	3.93
A_3V_1-A_3	21	72.38	89.33	4.31
A_1V_2-A_1	14	74.86	94.64	3.60
A_3V_2-A_3	17	67.47	85.82	3.31
A_1-A_1	21	64.38	82.43	2.81
A_3-A_3	21	67.62	86.90	

The mean reading levels of the deaf subjects in the five conditions used (not A_3-A_3) were 3.93, 4.31, 3.60, 3.31, and 2.81. The differences in reading levels among the groups were not considered serious since the results of Experiment VII showed that deaf subjects at the third and fourth grade reading levels did not differ significantly in performance on the visual tasks.

C. Results and Discussion

The mean number of correct responses on trials 1-5, 5-10, and 11-15 of the experimental conditions for both the normal-hearing and deaf subjects are shown in Table 8.2. These data are also presented in Figures 8.1 and 8.2.

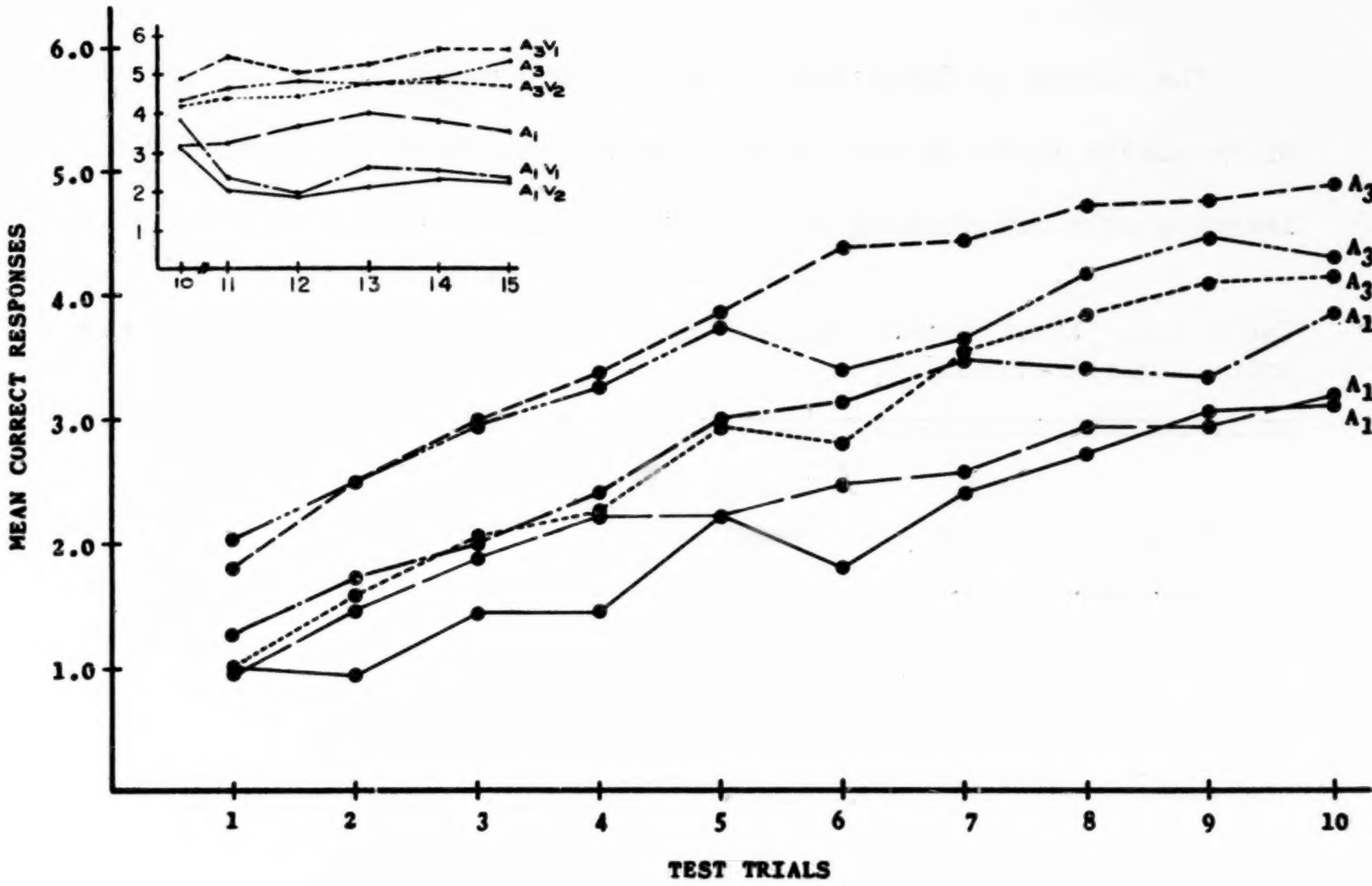

Fig. 8.1 Learning curves for standard conditions, trials 1-10, and for auditory component in inset, trials 11-15; grade 4.

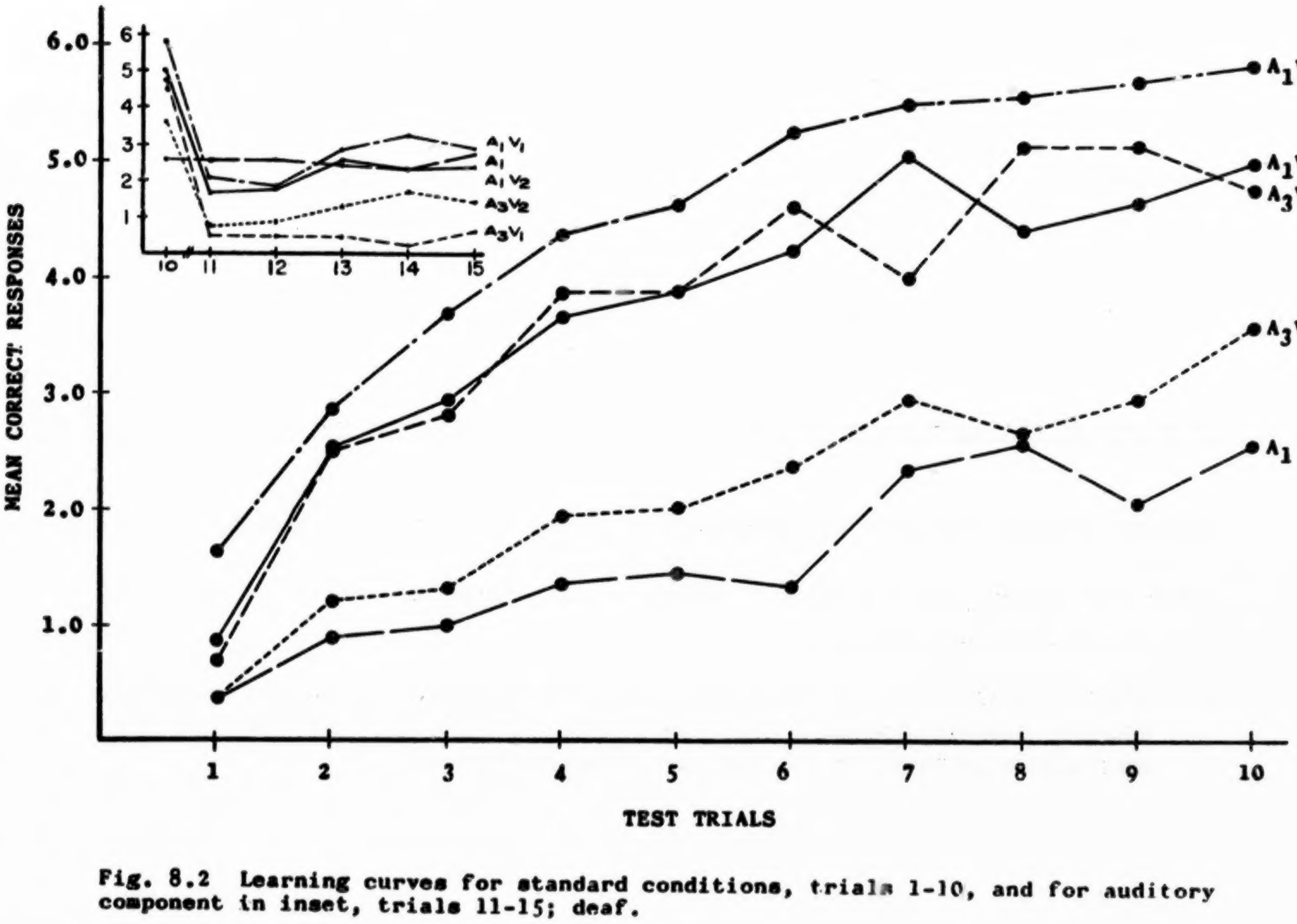

Fig. 8.2 Learning curves for standard conditions, trials 1-10, and for auditory component in inset, trials 11-15; deaf.

The values in Table 8.2 represent the average of the correct number of responses given by the subjects during a five-trial segment.[2] If learning were progressing in a systematic fashion each block of five trials should contain an increasing number of correct responses. The data for A_1-A_1 and A_3-A_3 for the normal subjects follow this trend

Table 8.2. Mean correct responses and standard deviations in five-trial units for each condition.

			Normal			Deaf	
Condition		1-5	6-10		1-5	6-10	11-15
A_1V_1-A_1	$\bar{X}$	10.40	17.20	11.90	17.19	27.81	13.00
	s	5.94	8.81	6.81	5.82	5.17	8.52
	N	30	30	30	16	16	16
A_3V_1-A_3	$\bar{X}$	14.58	23.26	27.06	13.75	23.63	2.83
	s	5.40	6.27	3.92	7.94	7.62	2.71
	N	31	31	31	16	16	16
A_1V_2-A_1	$\bar{X}$	7.15	13.15	10.62	13.88	23.35	10.76
	s	3.85	7.39	5.96	6.94	7.99	6.67
	N	26	26	26	17	17	17
A_3V_2-A_3	$\bar{X}$	9.93	18.54	23.11	6.84	14.53	6.05
	s	4.07	8.58	8.20	5.82	10.21	3.89
	N	28	28	28	19	19	19
A_1-A_1	$\bar{X}$	8.11	14.11	18.37	5.14	10.86	12.67
	s	3.73	7.23	7.76	3.47	7.42	9.08
	N	27	27	27	21	21	21
A_3-A_3	$\bar{X}$	14.48	19.97	24.55			
	s	8.57	9.03	7.57			
	N	33	33	33			

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[2] The presentation of the data in this fashion is for convenience in making comparisons to the last five trials and not because the task was administered in blocks of five trials.

representing an uninterrupted progression in learning. A similar trend is observed for A_3V_1-A_3 and for A_3V_2-A_3. However, for A_1V_1-A_1 and A_1V_2-A_1 the scores for the last five trials are less than for the second five trials. While the evidence does not justify the conclusion that attention was devoted exclusively to one modality or to the other, it is clear which modality was dominant. The same trends can be observed in Figure 8.1 where Inset A shows the learning at trial ten and for the following five trials.

Inspection of the data for the deaf subjects reveals that only with Condition A_1-A_1 is there a continuous progression of learning across the fifteen trials. As mentioned, no data are reported for Condition A_3-A_3 because the subjects were unable to discriminate the items. The difficulty which the deaf encountered with the simple, meaningful words is reflected in the scores of 2.83 and 6.05 in the last five trials for A_3V_1-A_3 and A_3V_2-A_3. A review of the data on the deaf suggests that they were using the visual modality predominantly regardless of meaningfulness. Furthermore, it is clear that the A_1 material was considerably easier for the deaf subjects than was the A_3 material.

Figure 8.3 gives a visual comparison of the performances of the deaf and normal-hearing fourth-grade subjects. The main part of the figure shows the total correct responses for the first ten trials, while the inset gives the same data for the last five trials. A study of the two parts of the figure in combination reveals some interesting trends. In the condition A_1V_1-A_1, the deaf are considerably superior on the first ten trials, which is in keeping with the report in Experiment VII that the deaf are superior to their normal grade counterpart on non-

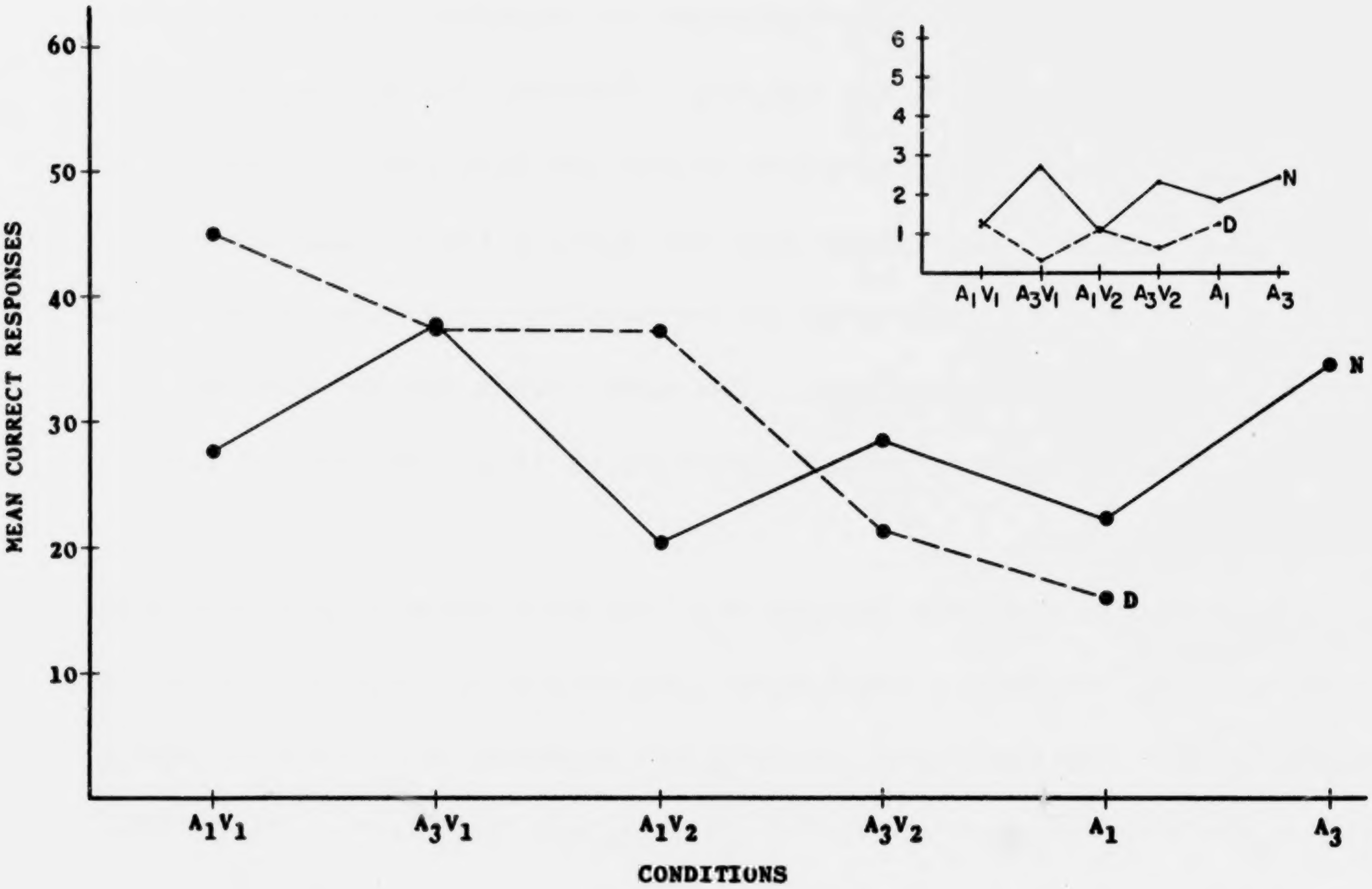

Fig. 8.3 Mean correct responses for standard conditions, trials 1-10, and for auditory component in inset, trials 11-15; normal and deaf.

meaningful visual symbols. Of particular interest is the fact that the deaf did as well on the auditory noises as did the normal subjects during the last five trials.

For the first ten trials of the A_3V_1-A_3 condition the two groups were essentially equal. A tentative inference would be that the deaf do about as well on nonmeaningful-nonverbal visual material as the normal subjects do on meaningful-verbal auditory material.[3] On the last five trials the normal subjects continued to improve their scores while the deaf dropped sharply. This would appear to be further evidence of the particular stimuli to which they were attending.

For Condition A_1V_2-A_1 it seems likely that both groups were attending primarily to the visual stimuli during the first ten trials since the performance for both groups dropped on trial eleven; yet they did about equally well on the auditory component for the last five trials. In the fourth condition (A_3V_2-A_3) where the auditory component consisted of meaningful words, the normal subjects performed slightly better on the first ten trials and markedly better on the last five trials. In Condition A_1-A_1 the normal subjects were better but the deaf subjects made reasonable progress; the differential was fairly constant across groups of trials.

In summary, these data seem to bear out the assumption that the performance of the normal-hearing subjects would be predictable on the basis of the meaningfulness of the material while the deaf in general followed the pattern of performing best on the visual task. However, the performance of the deaf subjects on the A_1 material was considerably better than expected in view of their hearing levels.

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[3] In Experiment VII another group of deaf subjects obtained initial scores of 51.5 on Condition V_1 which is between 10th and 12th grade performances of 48.8 and 54.0 on Condition V_3 and about equal to the 10th grade performance of 53.3 on Condition A_3.

Independent t-tests were used to evaluate the differences between the deaf and the normal-hearing groups; the results are given in Table 8.3. The groups did not differ on trials 1-10 of Conditions A_3V_1 and A_3V_2, yet the performances on trials 11-15 of these same conditions indicate that the deaf were not attending to the auditory component.

Table 8.3. Mean correct responses of five normal and five deaf groups and mean differences, by conditions.

Condition	Mean Score Trials 1-10		$\bar{X}$	Mean Score Trials 11-15		$\bar{X}$
	Normal	Deaf	N-D	Normal	Deaf	N-D
A_1V_1-A_1	27.60	45.00	-17.40**	11.90	13.00	- 1.10
A_3V_1-A_3	37.84	37.38	+ .46	27.06	2.83	+24.23**
A_1V_2-A_1	20.31	37.24	-16.93**	10.62	10.76	- .14
A_3V_2-A_3	28.46	21.37	+ 7.09	23.11	6.05	+17.06**
A_1-A_1	22.22	16.00	+ 6.22*	18.37	12.67	+ 5.70*

$*p < .05$; $**p < .01$

When neither channel was meaningful in content, as in Conditions A_1V_1 and A_1V_2, the normal subjects did not perform as well as the deaf during the combined trials, while the two groups are essentially equal on trials 11-15. The latter would suggest that neither group was attending to the auditory channel exclusively during the combined presentation. However, it may be inferred that, during the first ten trials, the deaf are attending chiefly to the visual material while hearing subjects may have been attempting to attend to both modalities either alternately or simultaneously.

In keeping with the assumption that the deaf subjects were using the visual modality almost exclusively when it was available to them, it is interesting to compare their scores over the first ten trials with the scores reported in the straight visual conditions in Experiment VII. The reading levels of the deaf subjects in the present experiment approximate the levels of the medium and/or low group of the previously reported experiment. For the combined conditions involving V_1 material, the subjects in the present experiment obtained scores of 45.00 and 37.38. The medium and low reading levels for the other deaf subjects had scores of 46.33 and 42.42. For the present group when the V_2 material was presented in combined conditions the scores were 37.23 and 21.37 while for the medium and low reading levels of the other study the scores were 32.92 and 31.42. These sets of scores are reasonably comparable. However, it is interesting that when the meaningful-verbal words are included the scores for the present group of deaf are poorer.

A series of statistical analyses were carried out to evaluate these observations. Correlated t-tests were used to evaluate the significance of the differences in mean performance between trial 10 and trial 11. The mean correct responses for the tenth and eleventh trials for the normal subjects along with the t-ratios are presented in Table 8.4. Only three of these comparisons are significant; A_1V_1-A_1 and A_1V_2-A_1 show a decrease in performance from trials 10 to 11, while A_3V_1-A_3 shows a significant increase. This finding is consistent with the hypothesis

Table 8.4. Mean scores at the transition from combined to auditory presentations for the normal groups.

Condition	Mean Score Trial 10	 Trial 11	$\bar{X}$ diff.	t
A_1V_1-A_1	3.87	2.37	-1.50	4.17**
A_1V_2-A_1	3.12	2.04	-1.08	2.84**
A_3V_1-A_3	4.90	5.45	+ .55	3.67**
A_3V_2-A_3	4.16	4.39	+ .23	.92
A_1-A_1	3.19	3.26	+ .07	.24
A_3-A_3	4.30	4.64	+ .34	1.55

**$p < .01$

that attention would be directed to the more meaningful channel in a bimodal presentation. The data for A_3V_1-A_3 suggest that the non-dominant channel in a bimodal condition might even exert an inhibitory effect on the learning of the meaningful channel. This finding may be a function of the stimuli, the modality, or it may reflect motivational factors. Graunke (1959) also reported an inhibitory effect with bimodal presentation.

The data for the deaf were treated in the same manner. The mean scores for trials 10 and 11 are presented in Table 8.5. Since there was a significant drop in performance in all four experimental conditions, the findings support the hypothesis that the visual channel is dominant to these subjects independent of the content of either channel in a bimodal presentation.

Separate analyses of variance were performed for the two groups for

Table 8.5. Mean scores at the transition from combined to auditory presentations for the deaf groups.

Condition	Mean Score Trial 10	 Trial 11	$\bar{X}$ diff.	t
A_1V_1-A_1	5.81	2.06	-3.75	8.15**
A_1V_2-A_1	5.00	1.65	-3.35	10.15**
A_3V_1-A_3	4.75	.50	-4.25	7.09**
A_3V_2-A_3	3.58	.74	-2.84	6.04**
A_1-A_1	2.57	2.57	0.00	0.00

**$p < .01$

each set of trials (1-10 and 11-15). The summary tables, presented in Table 8.6 for the normal groups and Table 8.7 for the deaf groups, indicate that conditions were a significant factor for both the normal-hearing and the hearing-handicapped groups on both sets of trials.

The individual means for the conditions used in the separate group by conditions analyses are presented in Tables 8.6 and 8.7 along with a summary of the Scheffe results showing the significance of the differences of the various means. All scores are ranked from the lowest on the left to the highest on the right for each condition. The normal-hearing subjects maintain a consistent rank order of the conditions for the first ten as well as the last five trials; there is only one reversal. In both instances, the conditions containing A_3 yielded the three highest scores. The deaf subjects, on the other hand, performed better on conditions containing V_1 for trials 1-10; the poorest performance was for A_1 where no visual component was presented. For trials 11-15, again

Table 8.6. Summaries of the two simple analyses of variance and of the Scheffe tests of trials 1-10 and 11-15 for the normal groups.

Trials	Source	df	MS	F
1-10	Conditions	5	1334.89	8.35**
	Within	169	159.90	
	Total	174		
11-15	Conditions	5	1359.40	29.05**
	Within	169	46.79	
	Total	174		

1-10	$\overline{X}$#	20.31	22.22	27.60	28.46	34.45	37.84
	Cond.	A_1V_2	A_1	A_1V_1	A_3V_2	A_3	A_3V_1
11-15	$\overline{X}$#	10.62	11.90	18.37	23.11	24.55	27.06
	Cond.	A_1V_2	A_1V_1	A_1	A_3V_2	A_3	A_3V_1

**$p < .01$. #Lines connect nonsignificant differences at $p = .05$.

only the auditory component being presented, the A_1 material was learned better than the A_3. It is interesting that the nonmeaningful noises were easier to learn than the three-letter words for the deaf subjects. Possibly the A_1 stimuli were simply easier to discriminate than the A_3 stimuli.

Attempts to collect data for Condition A3 with the deaf subjects were relatively unsuccessful. When the standard procedure was used in which no practice was given, it was apparent that the subjects were unable to discriminate the stimuli or responses in spite of the fact that they reported that they could hear the stimuli through the headsets.

The better performance with the A_1 stimuli as compared to A_3 may

Table 8.7. Summaries of the two simple analyses of variance and of the Scheffe tests of trials 1-10 and 11-15 for the deaf groups.

Trials	Source	df	MS	F
1-10	Conditions	4	2721.45	16.36**
	Within	84	166.37	
	Total	88		
11-15	Conditions	4	386.67	52.35**
	Within	89	43.45	
	Total	93		

1-10	$\bar{X}$#	16.00	21.37	37.24	37.38	45.00
	Cond.	A_1	A_3V_2	A_1V_2	A_3V_1	A_1V_1
11-15	$\bar{X}$#	2.86	6.05	10.76	12.67	13.00
	Cond.	A_3V_1	A_3V_2	A_1V_2	A_1	A_1V_1

**$p < .01$. #Lines connect nonsignificant differences at $p = .05$.

be a function of the difference in range of frequencies covered by the two sets of auditory stimuli, or it may reflect the early auditory training which the deaf receive in which various noisemakers are utilized. The data obtained for A_1 indicate that hearing-handicapped subjects respond differently to the stimuli than do subjects with normal hearing. An item analysis of the data from Experiment II (in Appendix C) showed that the stimuli associated with H and X were learned much more rapidly than the others, while M and V seem to be the most difficult to learn. This was not true with the deaf subjects where all items seemed to be learned equally well when summed over subjects. Again, there is great variability between subjects, possibly reflecting their hearing levels at various frequencies.

Experiment VIII provides further evidence on the contribution of the second modality in a bimodal presentation. With the hearing-handicapped subjects, if the visual component provided cues which aided in discriminating among the auditory stimuli, it would be apparent in the performance on the subsequent auditory trials. However, viewing the performance of the subjects on A_3V_1, it is seen in Table 8.7 that this condition is among those learned best when the visual component is present and among those learned least when only the auditory dimension is presented.

D. Summary and Conclusions

The major findings of this experiment were:

1. In a bimodal presentation, attention is directed chiefly to the channel which is most meaningful. For normal-hearing subjects, this is determined by the nature of the material; for hearing-handicapped subjects, the visual modality is more meaningful regardless of content.
2. The deaf performed about as well as the normal-hearing subjects on the nonmeaningful-nonverbal auditory material.

The three hypotheses which this experiment was designed to test have all been supported by the data. It would appear that children attend primarily to one dimension of a bimodal presentation, and that the modality which is preferred is a function of the meaningfulness of the modalities.

In this context, meaningfulness refers to the material being presented when subjects with normal hearing are considered. However, when hearing-handicapped subjects are considered, meaningfulness best refers to the modality itself rather than to the content in the modality.

SUMMARY AND CONCLUSIONS

A. Background

The present project is a continuation of a study on verbal learning in children, which was carried out from 1957 to 1960. The original project was designed to compare the efficiency of combined audio-visual presentations of material to be learned with presentations that were either auditory or visual alone. Meaningful material, simple nouns, were presented in paired-associate learning tasks to children with normal hearing in several grades and to groups of children classified by hearing levels. The results indicated that the combined audio-visual method of presentation was not superior to the single methods of presentation for either the normal-hearing or the hard-of-hearing subjects. Consistently, the hard-of-hearing subjects, even those with mild hearing losses, performed significantly poorer on the auditory presentations. At the conclusion of the original study, it was assumed that the fully meaningful character of the material to be learned may have obscured basic differences which exist among the three methods of sensory presentation of the material.

The plan of the present investigation was to extend the scope of the material to be learned to include nonmeaningful and nonverbal material as well as to extend the age range of the subjects studied. It was hypothesized that the study of the learning of nonmeaningful and nonverbal material would highlight differences between unimodal and bimodal presentations. Furthermore, such an approach would appear to have more direct relationship to the learning problems of the hard-of-hearing and deaf who are constantly faced with the task of acquiring new vocabulary without the benefit of having heard the items incidentally.

B. Objectives

The general objectives were to conduct an investigation of paired-associate learning when meaningfulness, verbalness, and sensory channel of presentation were varied.

More specifically, the data were expected to provide information concerning the following types of questions:

1. Does the performance on all types of paired-associate learning improve across age and grade levels?
2. Does the previously acquired information that children above the third grade perform equally well whether the material is presented auditorily, visually, or audio-visually hold for other than meaningful-verbal material?
3. Does the previously found superiority of auditory presentations in the lower grades hold for other than meaningful-verbal material?
4. Does the previously formulated hypothesis that the child tends to respond to paired-associate material either visually or auditorily but not bimodally hold for other than meaningful-verbal material?
5. What are the effects of shifting the subject from one sensory learning channel to another within a task and as a function of age?
6. Are the differences in performances of the children with hearing handicaps quantitatively related to their hearing levels or are the performances qualitatively different from normal?

C. Procedure

1. Apparatus. The basic apparatus included a tape recorder and a slide projector arranged so that paired-associate material could be presented auditorily, visually, or audio-visually to groups of children. Specifically, the visual material was put on slides, and the auditory

material was recorded on one channel of the tape recorder. Pulses were recorded on the other channel of the magnetic tape and served as the activating signals to operate the automatic slide projector. Thus, with the auditory material presented from the tape recorder and with the visual material controlled by signals on the magnetic tape, there were no problems in achieving a synchronous presentation of the audio-visual material or in presenting either the auditory or the visual independently, all with exactly the same apparatus and materials.

2. Test material. Operational definitions were formulated for four different types of material; viz., meaningful-verbal (MV), nonmeaningful-verbal (NMV), meaningful-nonverbal (MNV), and nonmeaningful-nonverbal (NMNV). Lists of materials were prepared for the MV, NMV, NMNV categories, but no logical set of material for the MNV condition was found. For purposes of symbolic representation, the Arabic numerals 1, 2, 3, were used as subscripts to represent NMNV, NMV, and MV, respectively. The capital letters A or V were used to designate the sensory channel of presentation. Thus, A_1 represents nonmeaningful-nonverbal material presented auditorily, and A_2V_2 refers to nonmeaningful-verbal material presented bimodally.

Six three-letter simple nouns were used for the meaningful-verbal stimulus material. Six pronounceable nonsense syllables, consonant-vowel-consonant, were used as the nonmeaningful-verbal stimuli. Standard electric and electronic symbols were modified and combined to make up the six nonmeaningful-nonverbal visual stimuli, and six unfamiliar noises were produced from the audio-generating equipment for use as the nonmeaningful-nonverbal auditory stimuli.

Six consonants, which were considered to have a minimum of visual and auditory similarities, were chosen as response items. The same set of letters were used with all conditions. During the actual group testing situations the response letters were written in answer booklets.

The test material and apparatus allowed the utilization of a total of fifteen conditions; three auditory (A_1, A_2, and A_3), three visual (V_1, V_2, and V_3), and nine combined or mixed conditions (for example, A_1V_1 and A_2V_3).

3. Subjects. All the testing for the project was done in group situations except for a small experiment involving pre-school children. The main body of data was gathered from grades 2, 3, 4, 5, 6, 7, 8, 10, and 12 in regular public schools. In addition, data were gathered for some conditions on children from several schools for the deaf. In all, over 5,000 subjects were tested as part of the project.

4. Procedure. For most experiments ten learning and ten test trials were utilized. During the learning trials, the stimulus item was presented followed by the appropriate paired response. During a test trial, only the stimulus members were presented and the children wrote the response item for each stimulus in turn, if they were able to recall it. Three separate arrangements of items were used for the presentation of the learning trials and for the test trials.

After the test booklets had been scored, the data were tabulated in such a way that the total number of correct responses made by a given child over the ten trials was combined with the scores from other children in the same condition to arrive at a mean-correct response score. The numbers of correct responses per trial were combined to arrive at learning curves for the various conditions.

D. Results

The project was carried out as a series of separate but related experiments. Each of the eight experiments is summarized briefly in the following subsections.

1. Experiment I. Stimulus familiarization; two conditions, two grades. Experiment I represented an attempt to generate meaningful-nonverbal material experimentally. The nonmeaningful-nonverbal stimuli (A_1 and V_1) were presented to groups of fifth and sixth-grade children for a series of familiarization trials prior to the standard task of ten learning and ten test trials. Specifically, five groups of sixth-grade subjects were given either 0, 3, 6, 9, or 12 familiarization trials on the A_1 material. Immediately upon the conclusion of the familiarization procedure, the learning and test trials were presented. No reasonable procedure was found for determining the degree of attention that the subjects paid to the auditory stimuli. For the visual familiarization, four groups of fifth-grade subjects were given either 0, 6, 9, or 12 familiarization trials on the V_1 material. With the visual material the subjects were given two minutes in which to draw from memory as many of the six stimuli as possible at the end of every third trial. Subsequent analyses reveal that the groups that had 6, 9, or 12 familiarization trials differed significantly in their ability to reproduce the symbols.

The main findings of the experiment were as follows:

a. On the auditory material the mean number of correct responses were 27.90, 30.41, 27.80, 24.55, and 32.90 for the five stimulus-familiarization groups from 0 to 12, respectively. The scores were not significantly different nor was there a trend for the scores to be better with increasing amounts of familiarization.

b. The mean correct responses for the four groups used in the visual familiarization tasks were 36.71, 34.50, 36,00, and 30.03 for the 0, 6, 9, and 12 trial groups, respectively. Again the differences were not statistically different nor did they relate systematically to the familiarization trials.

On the average, the group which had six familiarization trials on the visual material was able to draw 3.6 of the symbols correctly, the group which had nine trials was able to draw 4.5 symbols correctly, and the group which had twelve trials was able to draw 4.7 of the symbols correctly. In spite of the evidence of familiarity with the symbols, these three groups performed no better than the group which began the learning task without the preliminary experience with the symbols. The procedure used did not provide the stimuli with attributes which accelerated performance on the learning task.

On the basis of the data obtained, the attempt to generate meaningful-nonverbal material experimentally was abandoned.

2. Experiment II. Learning of nonmeaningful-nonverbal material; three conditions, six grades. Our earlier research had shown that there was little or no difference in the learning of meaningful paired-associate material that could be related to the sensory method of presentation. In general, the auditory and visual methods were equivalent and the combined audio-visual presentation was not superior. Furthermore, while the performances of the second and third-grade children were significantly below that of the children in the higher grades, there were no significant differences above the fourth grade. Experiment II was designed to determine whether the same general conclusions would prevail when the

test material was neither verbal nor meaningful.

The nonmeaningful-nonverbal material was presented as three conditions, A_1, V_1, and A_1V_1, to children in grades 3, 4, 5, 6, 7, and 8. Two classrooms of children were used for each condition.

The results from the experiment were as follows:

a. When the effects of grades were pooled, the visual and combined methods of presentation did not differ from each other; both were significantly better than the auditory.

b. There was general improvement in the scores from the third grade to the eighth grade.

c. Although the trends described in the first two conclusions were supported by the statistical analyses, the interaction between modalities and grades was significant and attests to certain inconsistencies in the trends.

The utilization of nonmeaningful-nonverbal material produced results that were in keeping with the previously formulated hypothesis that the combined audio-visual method of presentation is not superior to the better of the single auditory or visual methods. However, the consistent improvement across grades contradicts an earlier inference that one might expect a plateau in the performance at about the fourth grade.

3. Experiment III. Learning in grades 2-12; fifteen conditions. A large number of subjects, over 4,000, were used to test Conditions A_1, A_2, A_3, V_1, V_2, V_3, and the nine possible combinations of A-V. For these fifteen conditions, data were collected from subjects in grades 4, 5, 6, and 10. In addition, certain single and combined conditions were utilized with subjects from grades 2, 3, and 12.

All fifteen conditions were presented for the standard ten learning and ten test trials. For the combined audio-visual conditions, an eleventh trial was utilized in which only the auditory or the visual component was presented.

The main results from Experiment III were as follows:

a. When the data for all conditions were combined across grades, there was a consistent, almost linear, improvement in scores from grade 2 through grade 10. There appeared to be little additional improvement from grade 10 to grade 12.

b. Analyses of the data obtained with the unimodal auditory and visual presentations of the three types of materials revealed significant differences among the conditions across grades.

   The meaningful-verbal material produced the best scores, whether auditory or visual, and, with only an occasional exception, the pronounceable nonsense syllables were poorer than the nonmeaningful-nonverbal symbols.

c. Comparisons of bimodal versus unimodal presentations on nonmeaningful-nonverbal and nonmeaningful-verbal material revealed that the visual presentations yielded higher scores than the auditory presentations and that the audio-visual presentations were not superior to the visual.

   For the meaningful-verbal material, the combined presentations appeared superior to the auditory and the visual. However, this finding is considered to be an exception to the general trend of the data rather than evidence for the combined presentation.

d. When the scores for the fourth, fifth, sixth, and tenth grades were combined for the fifteen conditions, the conditions ranked as follows:

   (1) A_3V_3, (2) A_3V_1, (3) V_3, (4) A_3, (5) A_1V_3, (6) A_3V_2, (7) A_1V_1, (8) V_1, (9) A_2V_3, (10) A_2V_1, (11) V_2, (12) A_1V_2, (13) A_2V_2, (14) A_1, and (15) A_2.

   The meaningful-verbal material dominates the first six ranks, and the nonmeaningful-verbal material appears most frequently in the lowest seven ranks.

   The fact that sensory modality of presentation was not a major variable is illustrated by almost equal appearance of A and of V in the first seven and the last seven ranks.

e. An eleventh-trial analysis involving only the visual or the auditory component of a stimulus which had been presented bimodally for ten trials, corroborates the inference that the final score is more dependent upon the meaningfulness of the stimulus presented within a modality than upon the modality itself.

When meaningfulness is equal between sensory channels of presentation, the scores on the single component are equivalent whether auditory or visual.

The analyses of fifteen conditions across grades reveals clearly that meaningfulness was the most important variable involved in the present experiment. Verbalness in the absence of meaningfulness did not have a facilitative effect; however, the nonmeaningful-verbal lists may have been basically more difficult because of greater intra-list similarity. The effect of verbalness needs further study; the present experiment merely indicates that it is not an overriding variable.

4. Experiment IV. Learning in grades 5 and 6; two conditions. Our earlier research indicated a general equivalence of performance whether the presentation of the material was auditory or visual. Originally, it had been assumed that this conclusion needed to be limited to verbal material, but the data from Experiment III revealed the same general trends with nonsense syllables. In Experiment IV nonmeaningful-verbal material and meaningful-verbal material was presented to one group for five trials auditorily and then for five trials visually and to another group for five trials first visually and then auditorily. Two groups of fifth-grade and two groups of sixth-grade children were used on the nonmeaningful-verbal material and one group of fifth-grade children were used on the meaningful-verbal material.

The results which emerged from the experiment were as follows:

a. There appeared to be no differential effect in the overall performance whether the shift was from auditory to visual or visual to auditory within a given task.

b. When the material was nonmeaningful-verbal, there was a temporary but significant decrement in the performance between the fifth and sixth trials when the shift was from auditory to visual. No such decrement was observed when the shift was from visual to auditory.

   Although no control condition was included, there was the possibility that the overall performance with the nonsense syllables might have been better if the presentation had been visual throughout.

Although the present experiment supported the hypothesis that shifting modalities in the middle of a task would have little or no effect, it is felt that this inference must be limited to the materials and procedures used here. The level of difficulty of the material itself or the stage in the learning task in which the shift is made, or both, may be variables which would alter this finding.

5. Experiment V. Learning in kindergarten and first grades; six conditions. Conditions A_2, A_3, V_1, V_2, V_3, and a new condition V_{3P} utilizing pictures in place of words were presented to groups of children in kindergarten and first grade. The experiment demonstrated that paired-associate learning tasks could be presented successfully to groups of ten kindergarten or first-grade children. The use of multiple choice answers rather than write-down procedures probably contributed to the success. The results of the experiment were as follows:

a. The first-grade children performed better than the kindergarten children on all conditions, although all differences were not statistically significant.

b. Best performance of all for both groups occurred when meaningful-verbal material was presented auditorily.

c. Even though it was presumed that both age groups of children were unable to read, the auditory presentation of nonsense syllables was not better than the visual presentation.

d. Although the performance for the first-grade children on the printed words was better than for the kindergarten children on the same condition, there were no significant differences between performances with nonsense syllables and meaningful words presented visually.

An earlier inference that the young school-age child is primarily auditory is confirmed in part. The conclusion applies when the material is meaningful. When meaning has yet to be attached, words are not easier than nonsense syllables and auditory presentation is not superior to visual.

6. Experiment VI. Pre-school children; three conditions. Three auditory conditions were presented to three groups of children between three and five years of age. The experiment was considered a pilot approach to the testing of children below school age. With proper modifications in the method of presentation and using individual testing, reasonably satisfactory results were obtained. The conclusions drawn from the study were:

a. Better scores were obtained on the meaningful material than on the nonmeaningful-verbal, although the differences were not found to be statistically significant, probably due to the small sample sizes.

b. The performance of the pre-school children was not significantly different from either the kindergarten or first-grade subjects when learning nonsense syllables by an auditory presentation. The scores for the kindergarten and first-grade pupils were better when the material was meaningful words. However, both comparisons may be confounded by changes in methodology.

The purpose of the study with pre-school children was primarily to assess the difficulties which would be encountered in conducting studies with children in this age range. With proper modifications in apparatus and procedure, it appears that satisfactory data can be gathered.

7. Experiment VII. Learning in a school for the deaf; three visual conditions. Conditions V_1, V_2, and V_3 were presented to three groups of children in a school for the deaf. Each group consisted of four children at three reading levels, and each group learned all three lists in a different order. The results of the experiment were as follows:

a. The subjects from the school for the deaf performed as well or better than normal-hearing subjects of comparable reading levels on all three visual tasks.

b. The deaf subjects performed especially well on the nonmeaningful-nonverbal visual symbols. Even though their average reading level approximated the fourth or fifth grade, their performances on this material were equal to that of twelfth-grade normal-hearing subjects.

With one exception, the deaf subjects performed at or slightly above the sixth-grade normal-hearing subjects on the nonmeaningful-verbal and meaningful-verbal material.

In some ways, the data gathered for this experiment were not completely comparable with the data gathered on normal-hearing subjects, since repeat measures were used with the deaf subjects. However, whether the scores are limited to the group which had initial contact with the task in a given condition or to the averages across conditions, the above general conclusions hold. One exception occurred. The group which started the learning task with Condition V_2 performed quite poorly obtaining a total average of 18.4. It is not clear whether this finding is specifically related to the sample utilized or whether the deaf have unexpected difficulty in learning such a task when the material involves nonsense syllables. It was interesting that two of the three groups performed better with the nonmeaningful-nonverbal symbols than with the meaningful-verbal words.

8. Experiment VIII. Learning in the fourth grade and in schools for the deaf; six conditions. Four combined audio-visual conditions were presented for ten trials followed by five additional trials using the auditory component alone. Two auditory conditions were presented for fifteen trials as a control. Six groups of normal fourth-grade children and six groups of children from two schools for the deaf served as subjects in the experiment. It was assumed prior to the onset of the experiment that the performance between the tenth and eleventh trial would give an indication of the degree to which the auditory component had been utilized in the previous ten trials and further, that the performance in the last five, auditory only, trials would give some indication of the ultimate potential to utilize the auditory modality. The following six conditions were used: A_1V_1-A_1, A_1V_2-A_1, A_3V_1-A_3, A_3V_2-A_3, A_1-A_1, and A_3-A_3. Basically, the symbolization is the same as used in the other experiments except that the hyphen and the final symbol represent the change which took place between the tenth and eleventh trials and the type of material which was presented for the final five trials.

The major findings from the experiment were:

a. In a bimodal presentation, attention is directed chiefly to the channel which is most meaningful. For normal-hearing subjects, this is determined by the nature of the material; for deaf subjects, "meaningfulness" seems to be the material which is presented visually.

b. The particular set of deaf subjects utilized were unable to learn the meaningful-verbal words with any degree of success in any of the three conditions. However, their performance with the nonmeaningful-nonverbal auditory noises was about as good as that of the normal-hearing subjects.

Because the deaf subjects utilized in Experiment VIII all had severe hearing losses and were enrolled full-time in a residential school for the deaf, the results obtained cannot be generalized to children with lesser hearing handicaps. However, as far as the groups themselves were concerned, it was considered surprising that they performed almost as well as normal subjects on the auditory noises but were unable to perform with any degree of success on the simple three-letter words when presented auditorily. Further research is necessary to determine whether these findings can be explained simply on the basis of differential in ease of discrimination between the two lists or whether it might, in part, be related to inadequate training in the discrimination of meaningful auditory material.

D. Conclusion

In an extensive study of paired-associate learning in children with normal hearing and with severe hearing losses in which the material has been presented auditorily, visually, and audio-visually and in which meaningfulness and verbalness have been varied, the conclusion which emerges again and again is that meaningfulness, as defined here, is the most important variable that was manipulated. The most surprising finding in the research was the lack of influence of verbalness upon the results. However, since intra-list similarity and discriminability were not controlled experimentally, further research is needed before final assessment can be made of the relative importance of these variables.

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APPENDICES

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Appendix A. Learning Curves for Conditions by Grades from Experiment III 165

Appendix B. Summary Tables for Analyses of Simple Effects for Experiment III 173

Appendix C. Item Analyses for Selected Stimulus Pairs 178

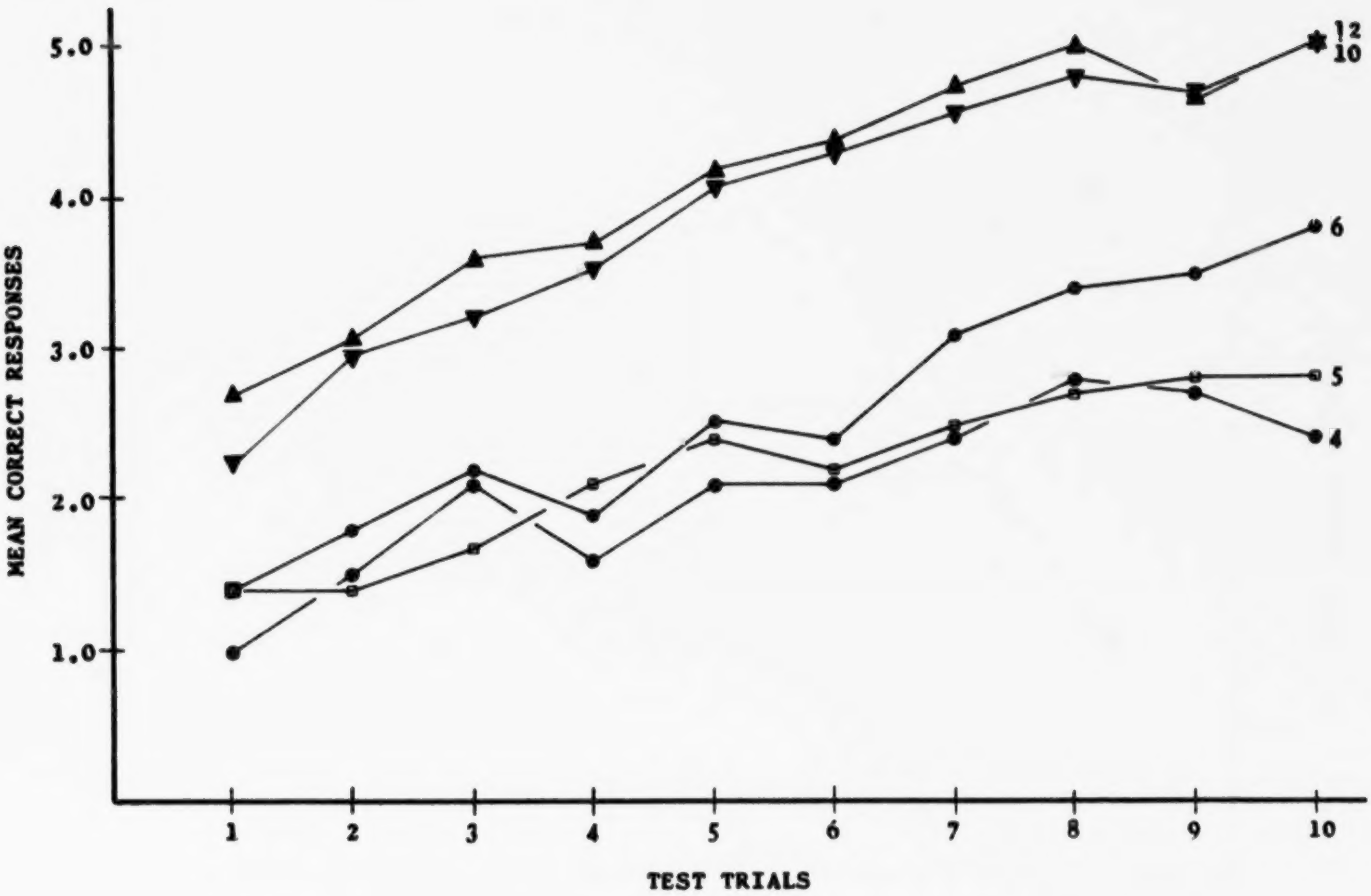

Fig. A.1 Learning Curves for Condition A_1, by grades.

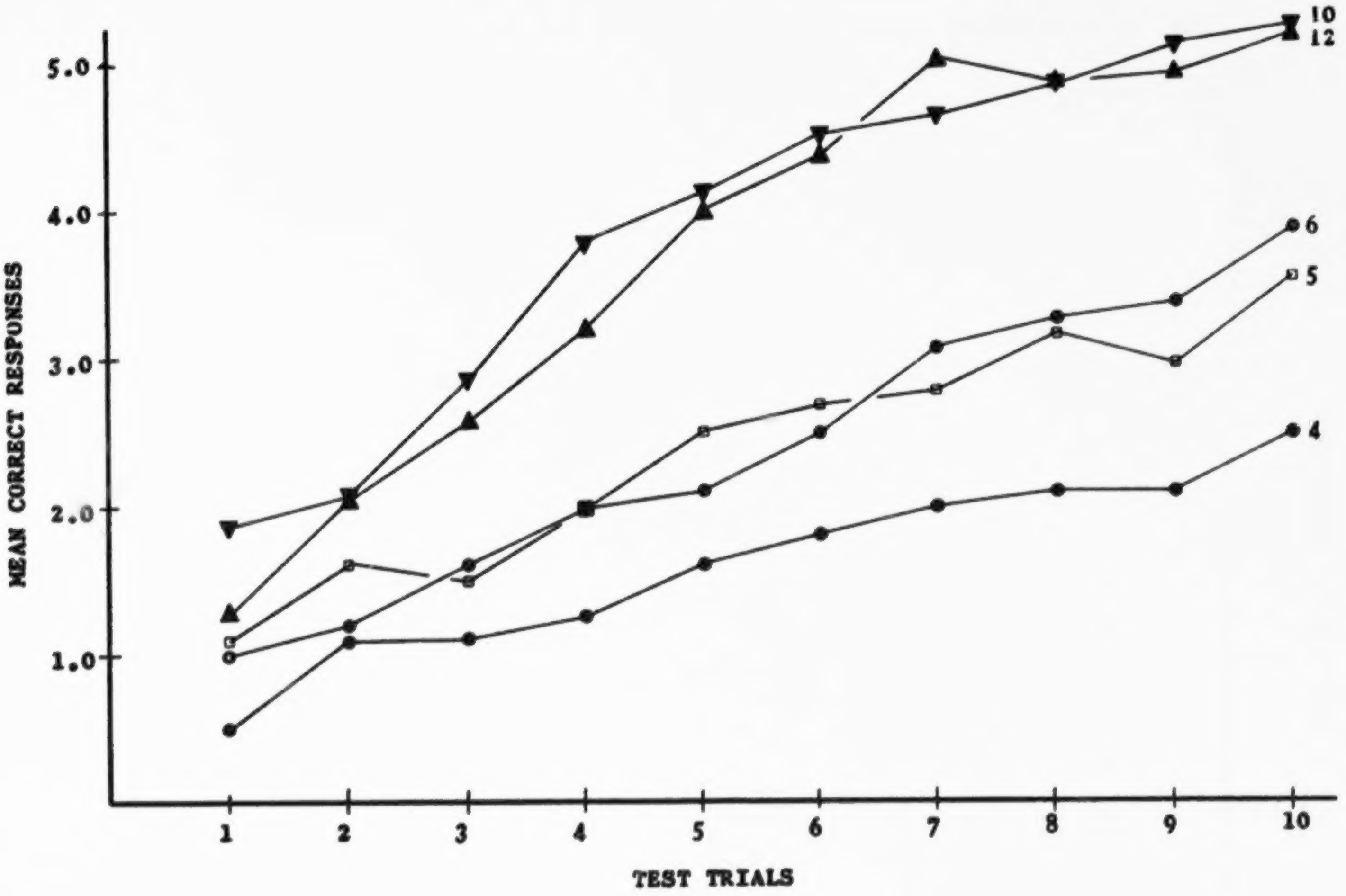

Fig. A.2 Learning curves for Condition A_2, by grades.

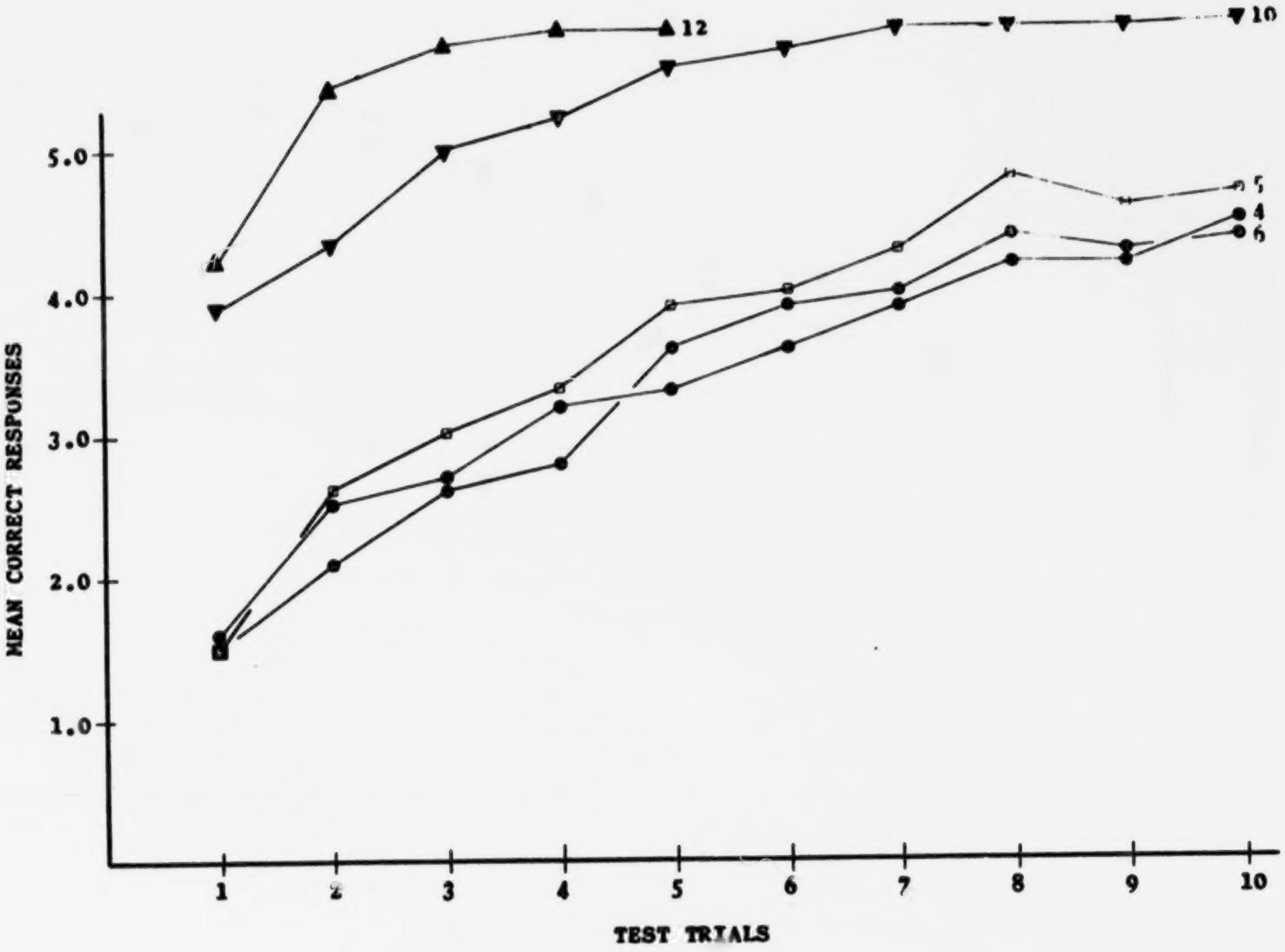

Fig. A.3 Learning curves for Condition A_3, by grades.

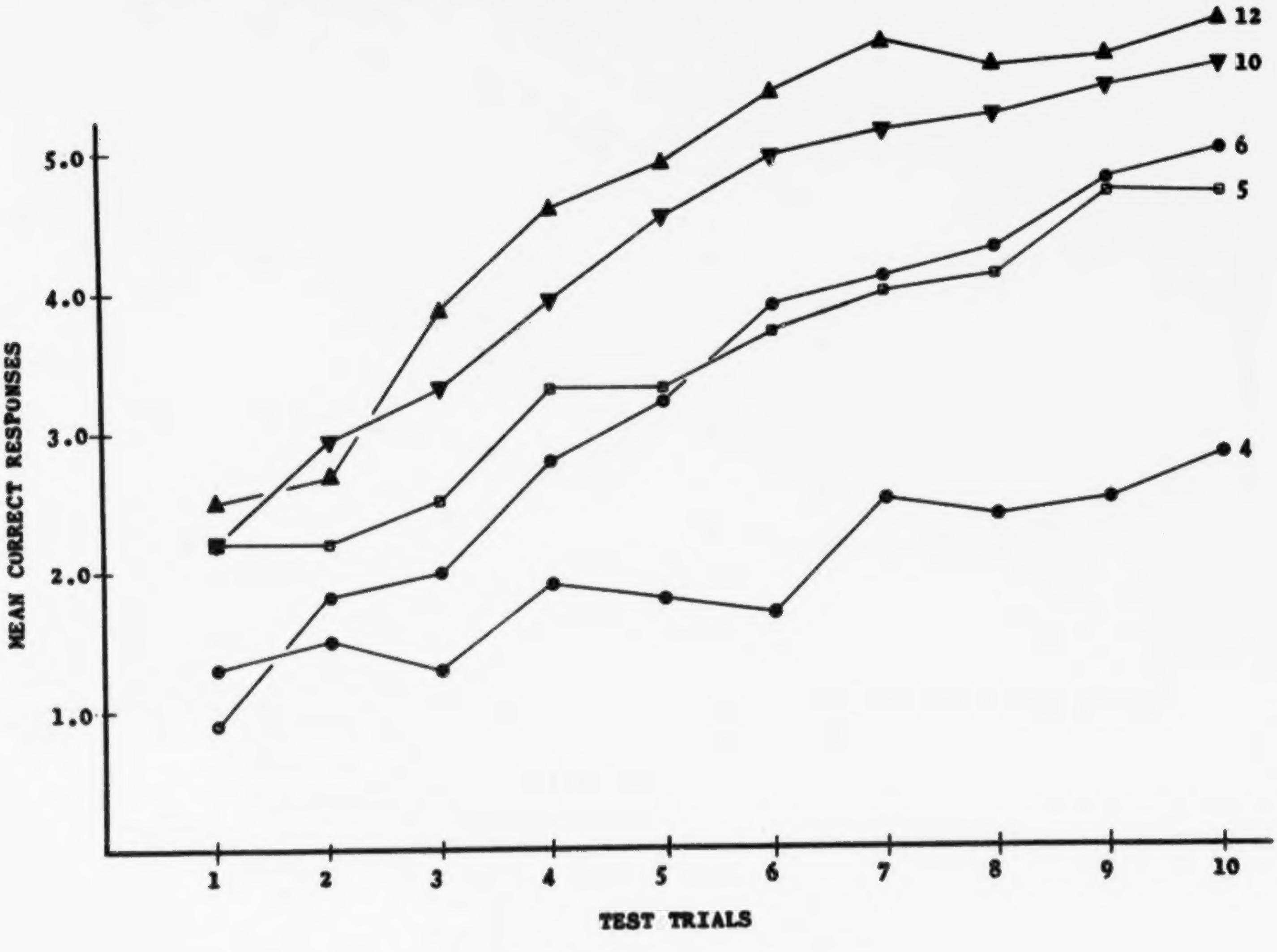

Fig. A.4 Learning curves for Condition V_1, by grades.

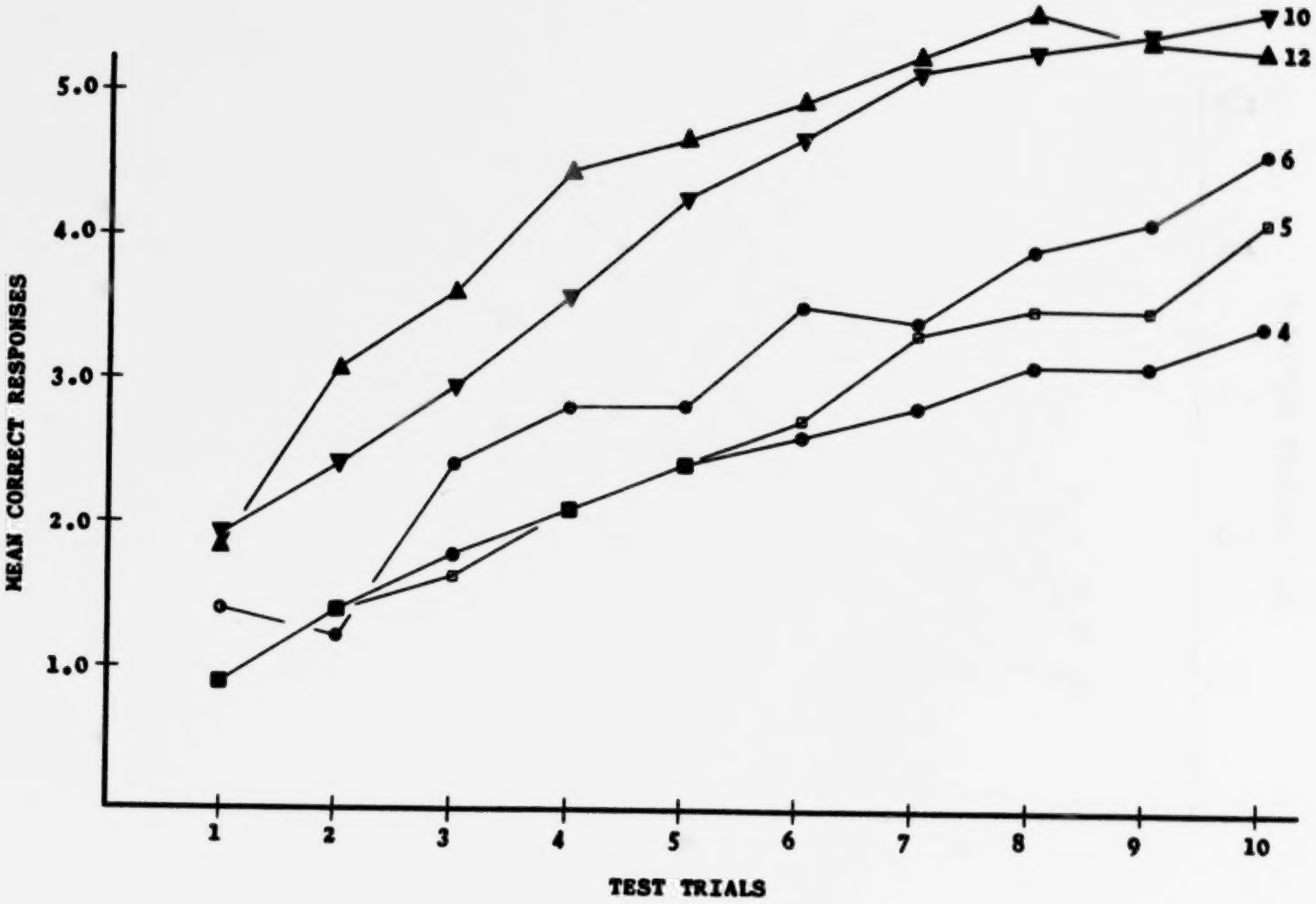

Fig. A.5 Learning curves for Condition V_2, by grades.

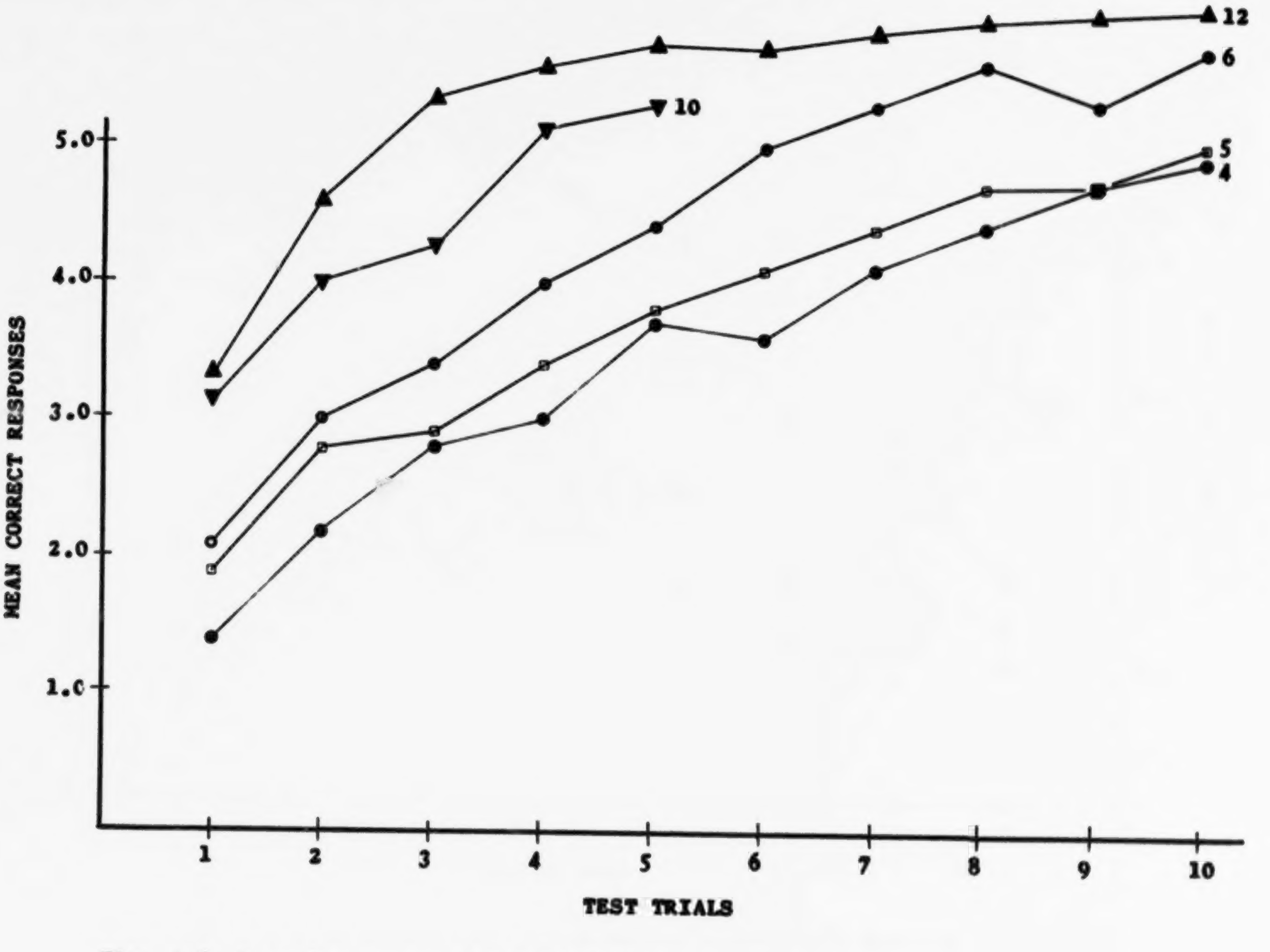

Fig. A.6 Learning curves for Condition V_3, by grades.

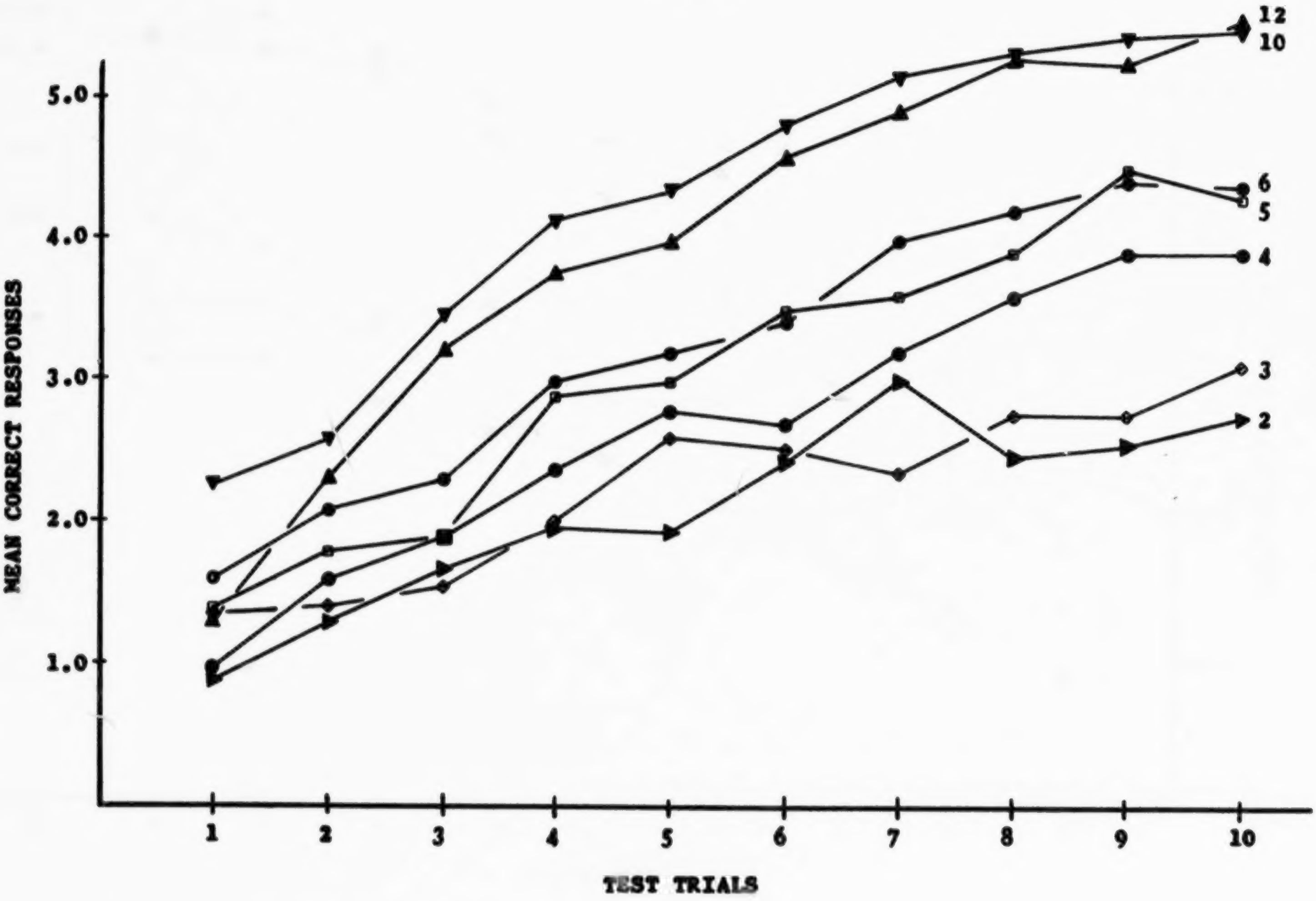

Fig. A.7 Learning curves for Condition A_1V_1, by grades.

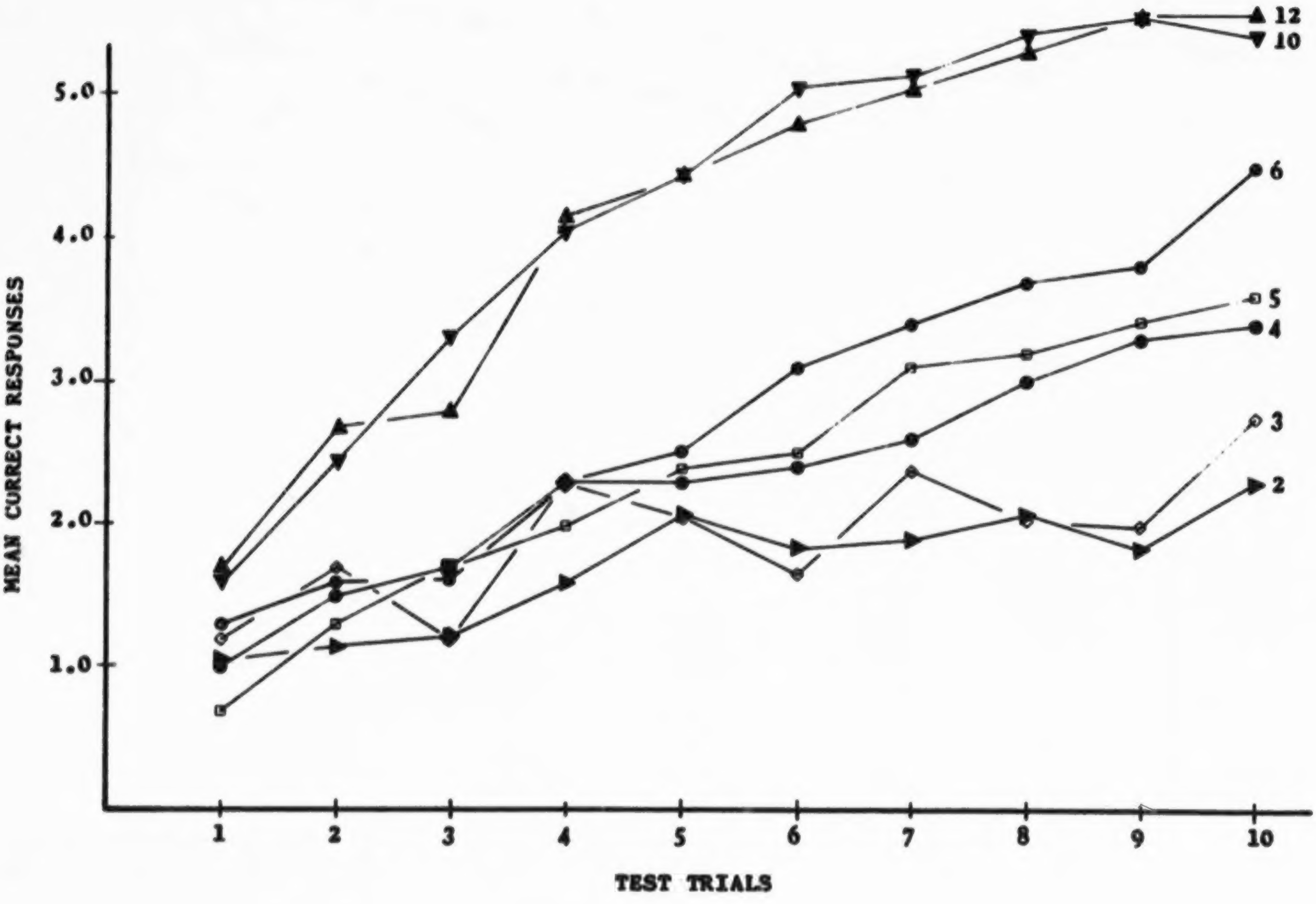

Fig. A.8 Learning curves for Condition A_1V_2, by grades.

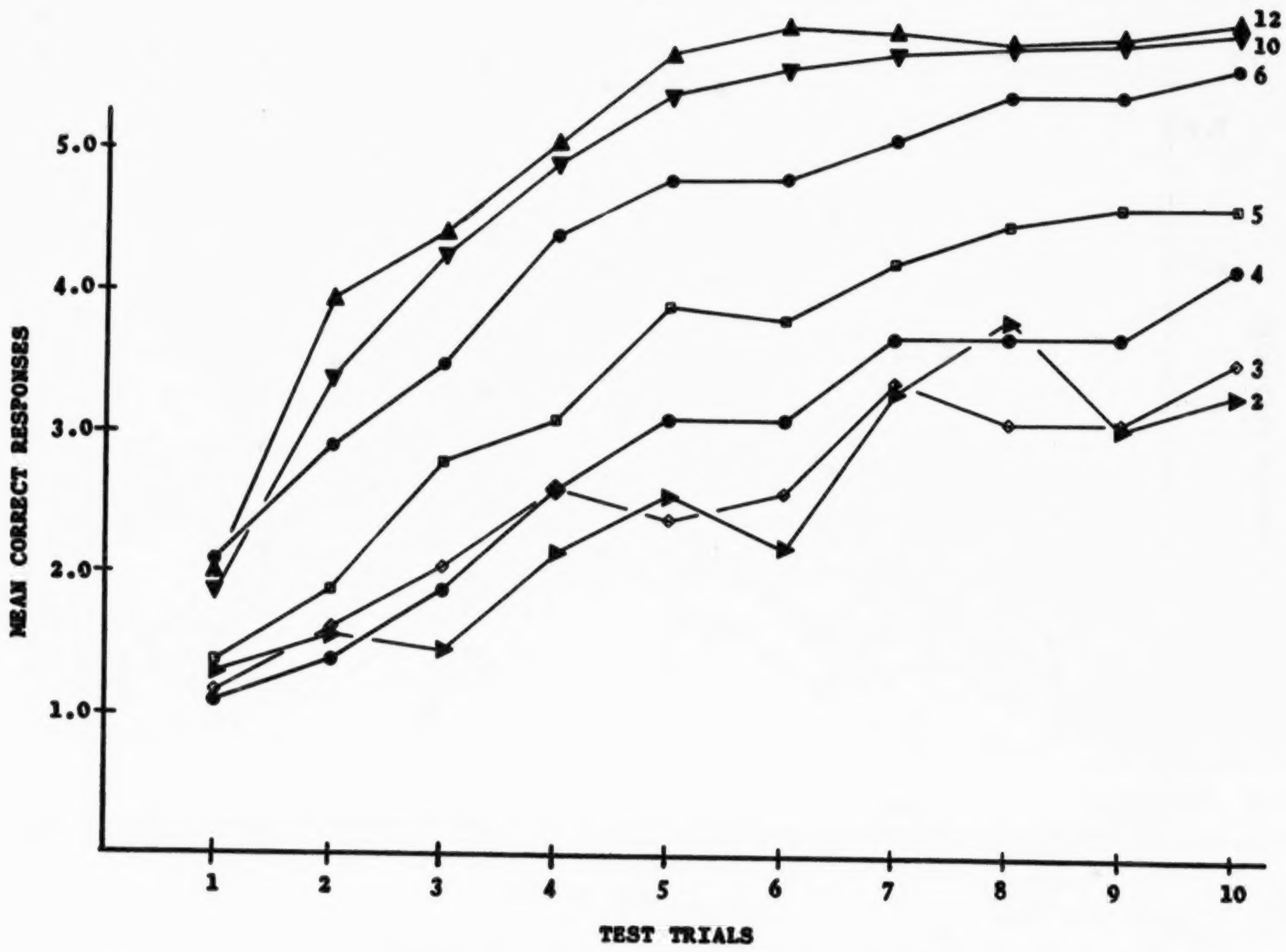

Fig. A.9 Learning curves for Condition A_1V_3, by grades.

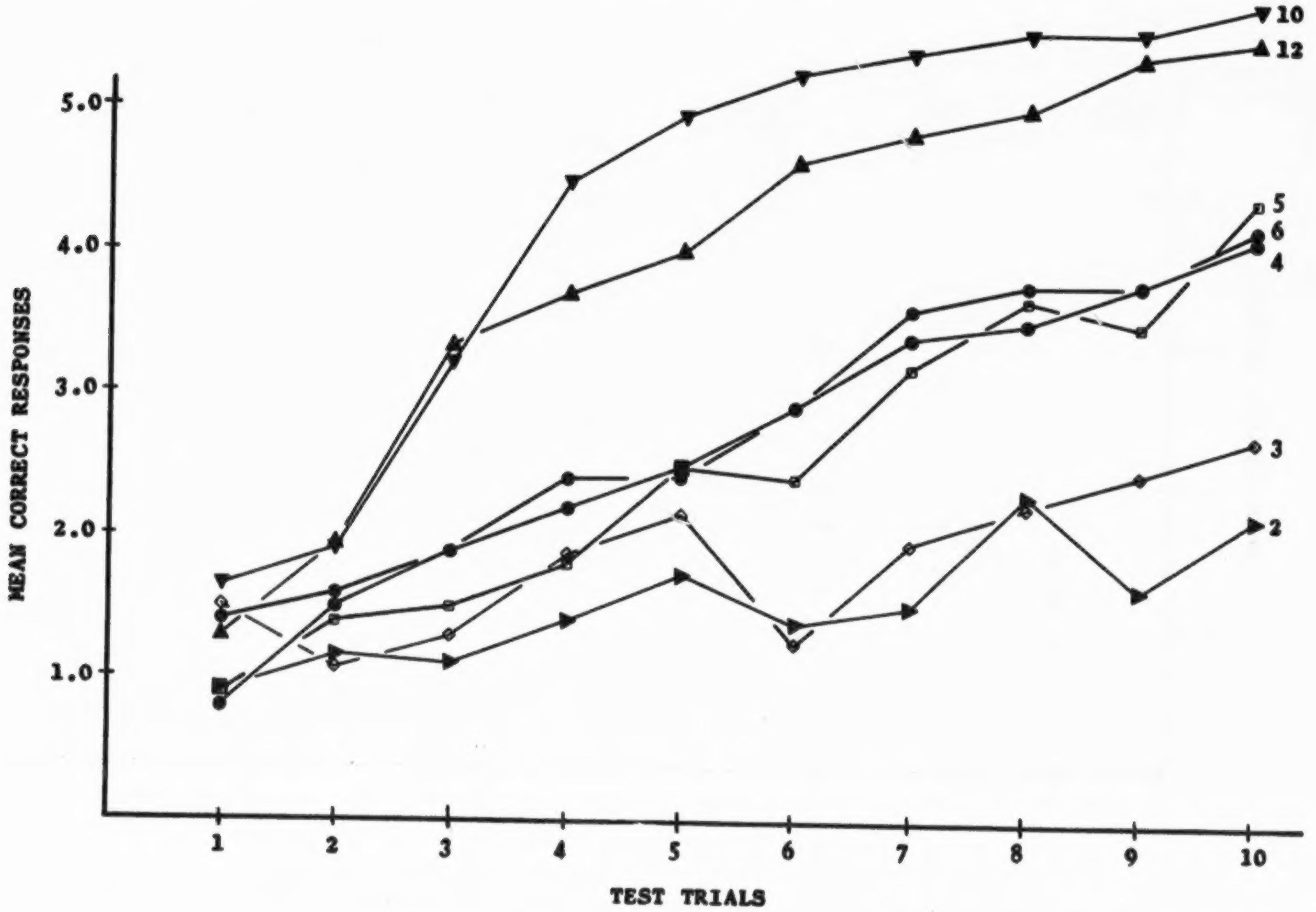

Fig. A.10 Learning curves for Condition A_2V_1, by grades.

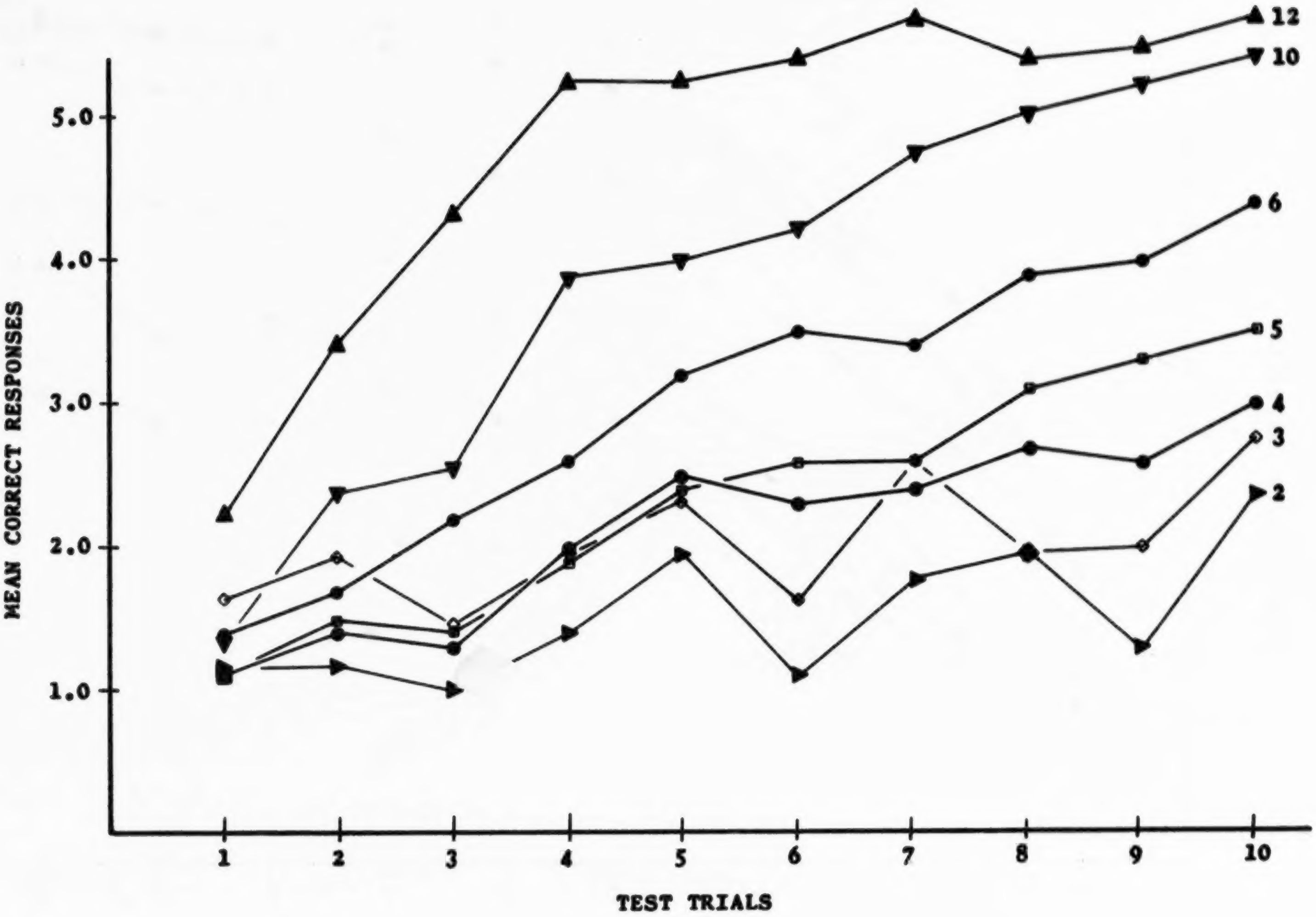

Fig. A.11 Learning curves for Condition A_2V_2, by grades.

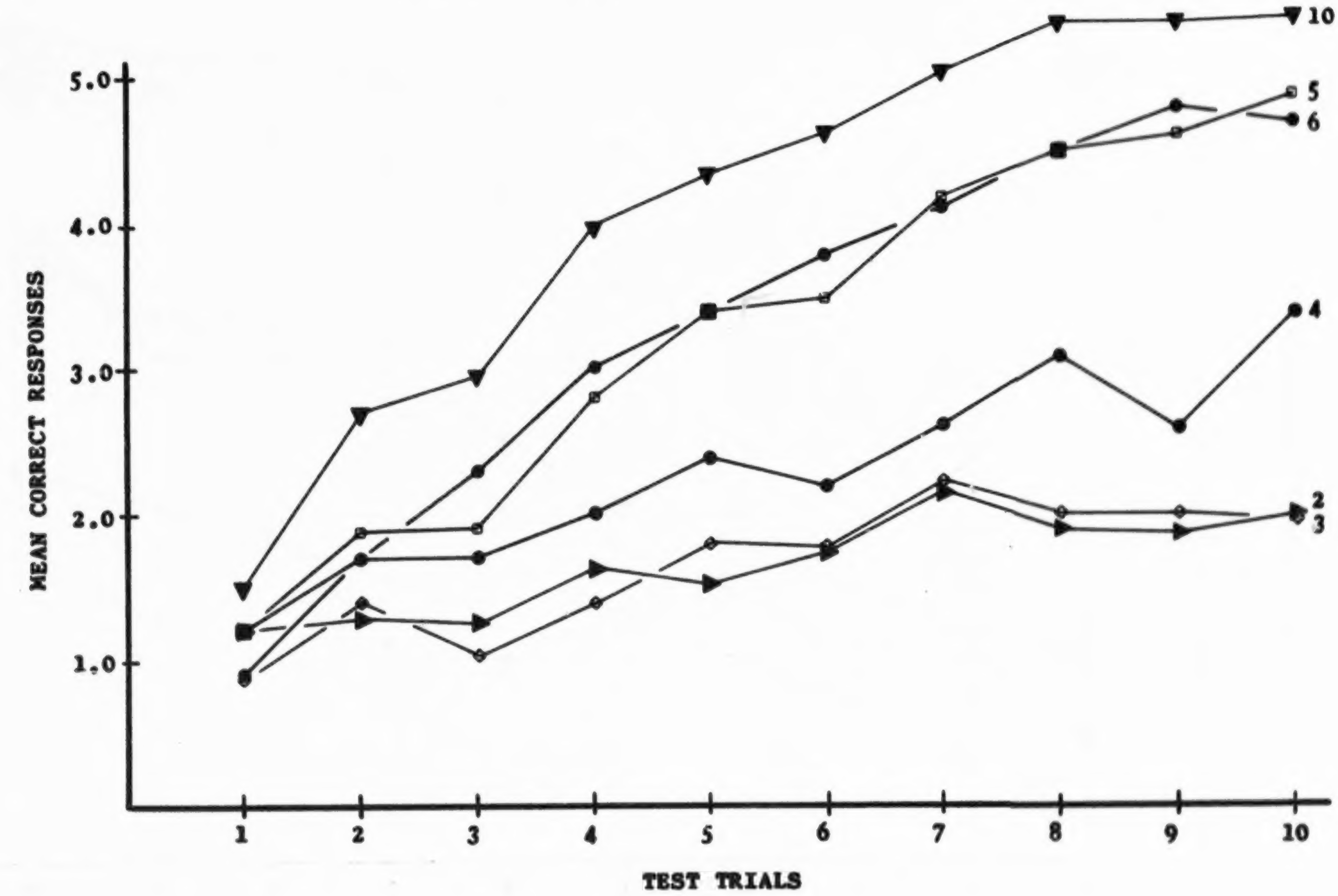

Fig. A.12 Learning curves for Condition A_2V_3, by grades.

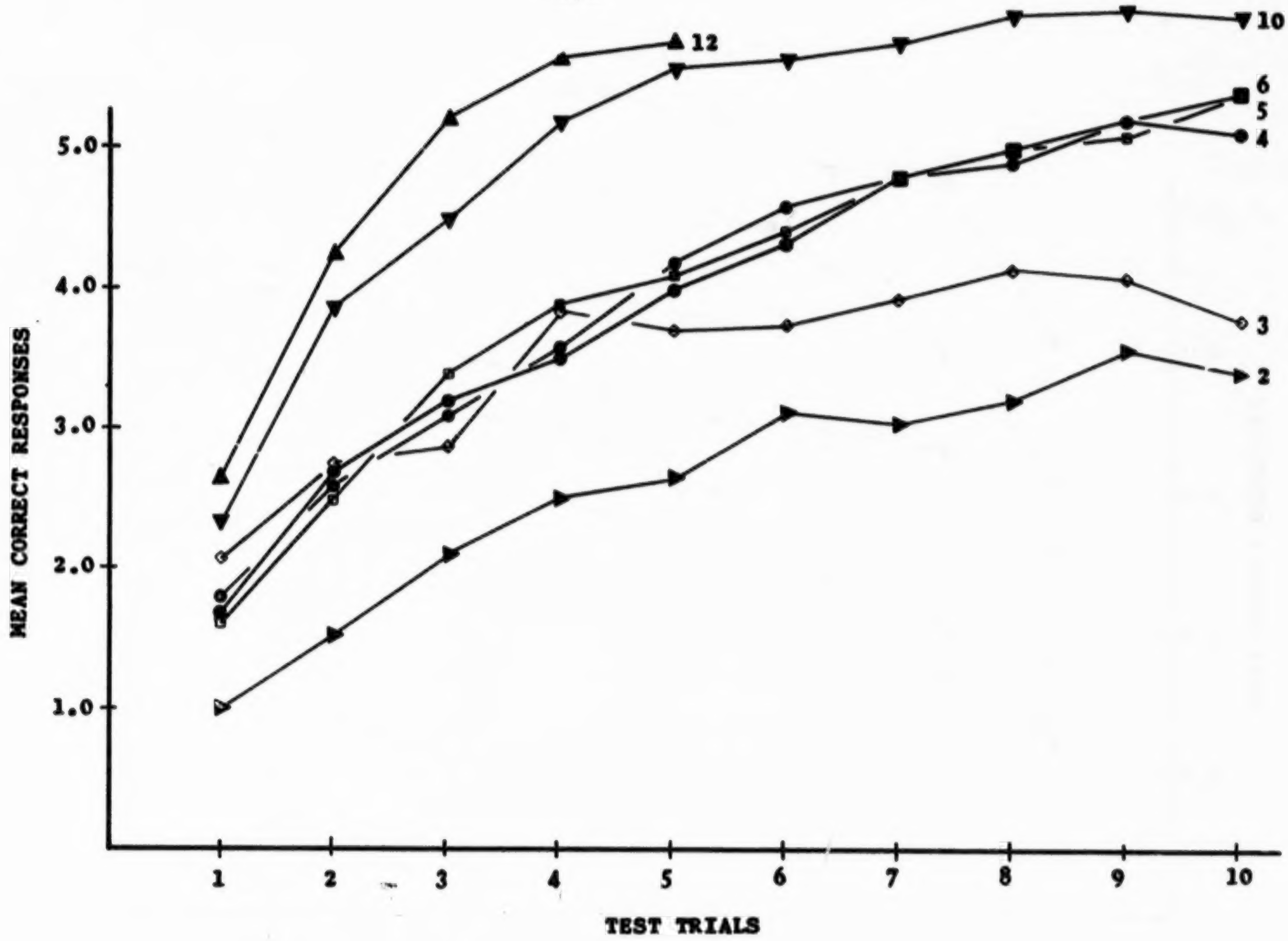

Fig. A.13 Learning curves for Condition A_3V_1, by grades.

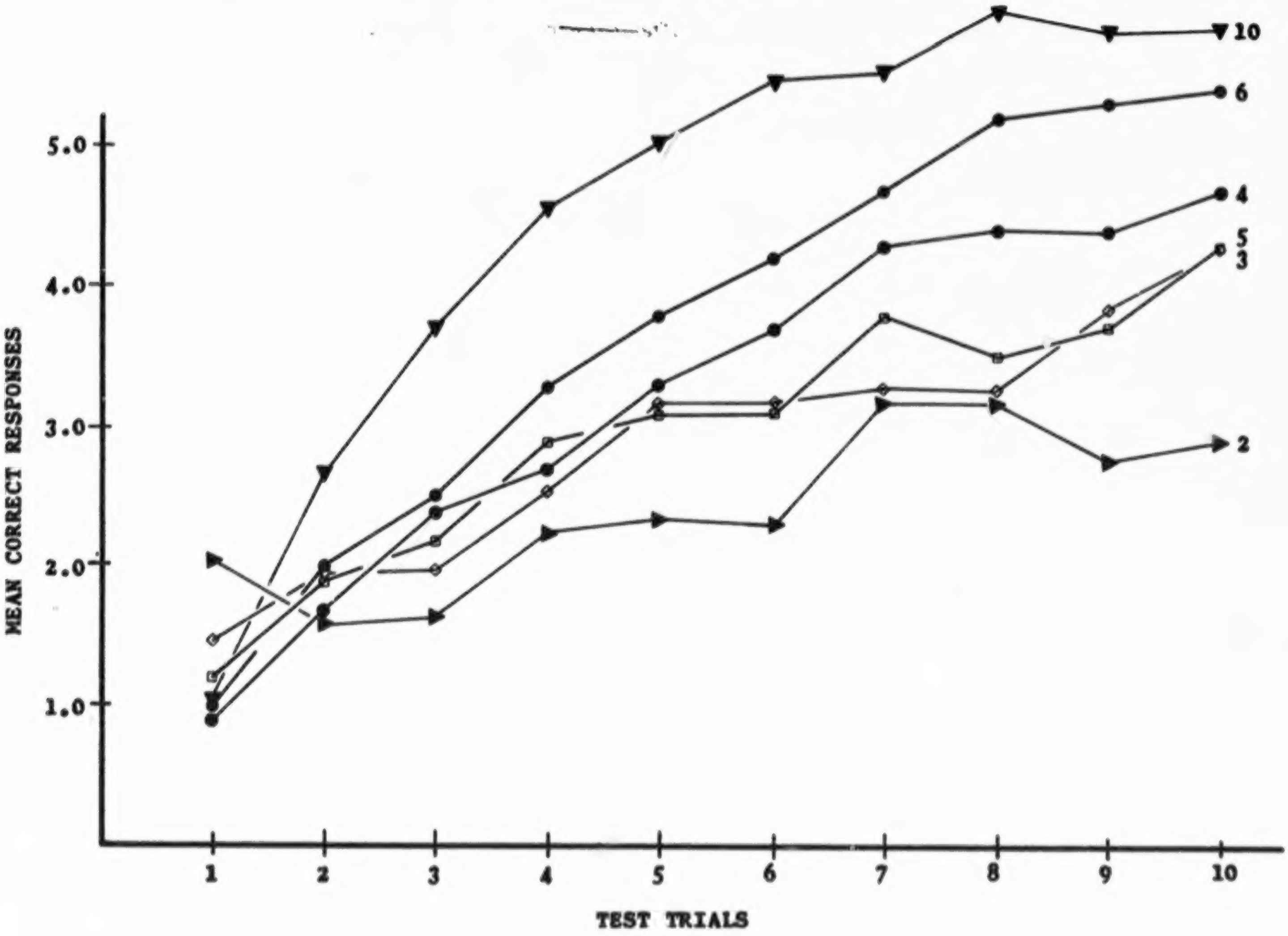

Fig. A.14 Learning curves for Condition A_3V_2, by grades.

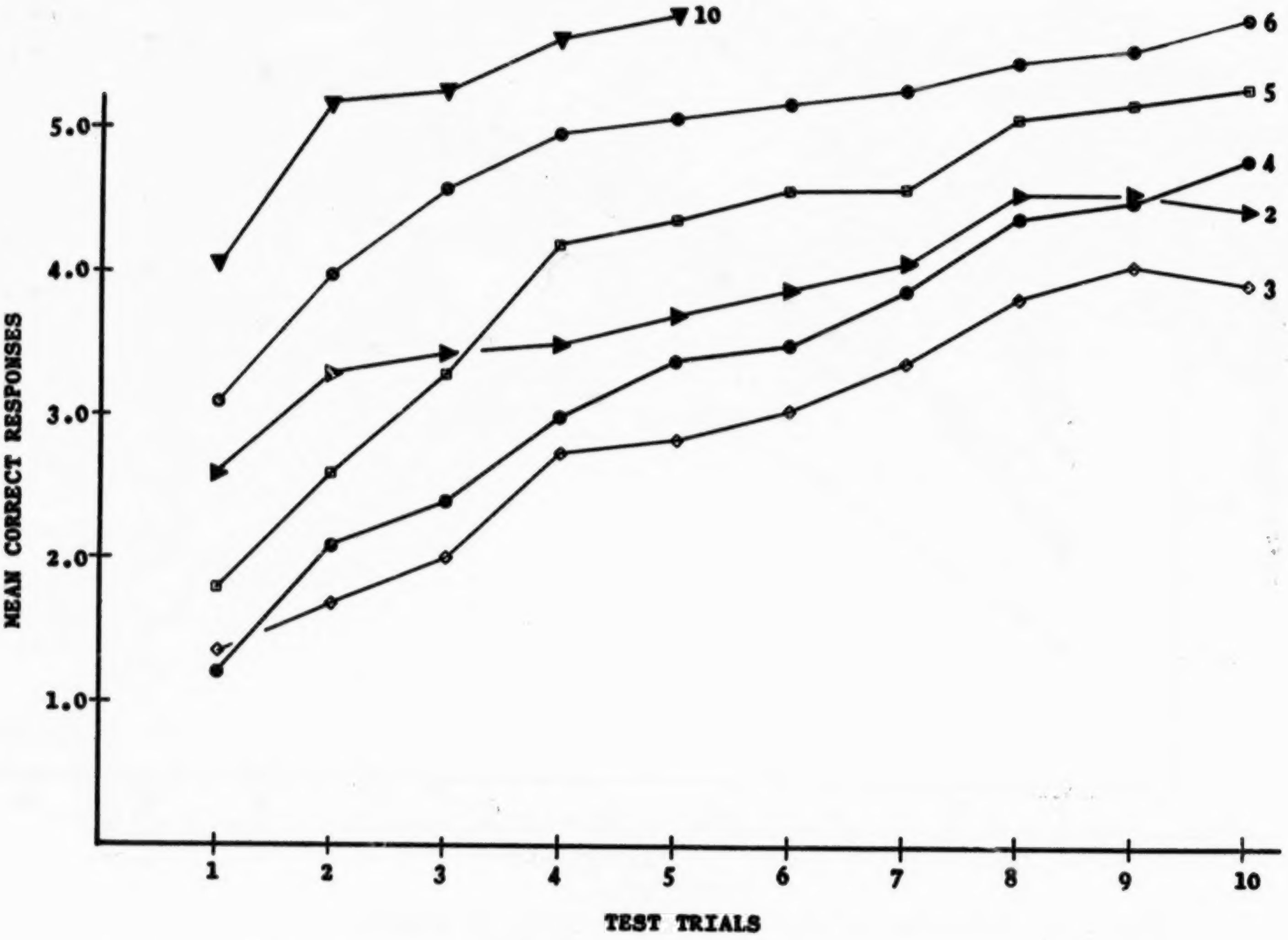

Fig. A.15 Learning curves for Condition A_3V_3, by grades.

Table B.1 Summary of the analyses of simple effects and of the Scheffe tests, for the three visual conditions and five grades.

GRADES

Condition Held Constant	df	MS	F	Scheffe#
V_1	4	5055.92	34.21**	4 6 5 10 12**
V_2	4	3856.36	26.10**	4 5 6 10 12**
V_3	4	2703.18	18.29**	4 5 6 10 12**

CONDITIONS

Grades Held Constant	df	MS	F	Scheffe#
4	2	2812.73	19.03**	V_1 V_2 V_3**
5	2	1895.24	12.82**	V_2 V_1 V_3*
6	2	2368.42	16.03**	V_2 V_1 V_3**
10	2	687.78	4.65**	V_2 V_1 V_3*
12	2	1167.97	7.90**	V_2 V_1 V_3*

* $p < .05$; ** $p < .01$.

# Rank order, low to high. Line connects nonsignificant differences when $p = .05$ or $.01$.

Table B.2 Summary of the analyses of simple effects and of the Scheffe tests, for the three combined conditions, which include A_1, and seven grades.

GRADES

Condition Held Constant	df	MS	F	Scheffe#
A_1V_1	6	2727.30	19.83**	2 3 4 5 6 12 10**
A_1V_2	6	4195.67	30.51**	2 3 4 5 6 12 10*
A_1V_3	6	4796.40	34.88**	2 3 4 5 6 10 12**

CONDITIONS

Grades Held Constant	df	MS	F	Scheffe#
2	2	433.89	3.15*	A_1V_2 A_1V_1 A_1V_3*
3	2	368.61	2.68	
4	2	240.19	1.75	
5	2	1223.99	8.90**	A_1V_2 A_1V_1 A_1V_3*
6	2	2651.76	12.28**	A_1V_2 A_1V_1 A_1V_3**
10	2	405.03	2.95	
12	2	1145.35	8.33**	A_1V_2 A_1V_1 A_1V_3*

* $p < .05$; ** $p < .01$.

# Rank order, low to high. Line connects nonsignificant differences when $p = .05$ or $.01$.

Table B.3 Summary of the analyses of simple effects and of the Scheffe tests, for the three combined conditions, which include A_3, and six grades.

GRADES

Condition Held Constant	df	MS	F	Scheffe#
A_3V_1	5	2845.79	18.56**	2 3 4 5 6 10*
A_3V_2	5	2562.00	16.71**	2 3 5 4 6 10*
A_3V_3	5	4416.01	28.80**	3 4 2 5 6 10*

CONDITIONS

Grades Held Constant	df	MS	F	Scheffe#
2	2	2554.55	16.66**	A_3V_2 A_3V_1 A_3V_3*
3	2	479.08	3.12*	A_3V_3 A_3V_2 A_3V_1*
4	2	672.26	4.38	A_3V_2 A_3V_3 A_3V_1*
5	2	1812.42	11.82**	A_3V_2 A_3V_1 A_3V_3*
6	2	1725.67	11.26**	A_3V_2 A_3V_1 A_3V_3*
10	2	1037.62	6.77**	A_3V_2 A_3V_1 A_3V_3*

* $p < .05$; ** $p < .01$.

# Rank order, low to high. Line connects nonsignificant differences when $p = .05$ or $.01$.

Table B.4 Summary of the analyses of simple effects and of the Scheffe tests, for the three combined conditions, which include V_3, and six grades.

GRADES

Condition Held Constant	df	MS	F	Scheffe#
A_1V_3	5	4637.34	32.89**	2 3 4 5 6 10**
A_2V_3	5	4588.58	32.54**	3 2 4 5 6 10**
A_3V_3	5	4325.12	30.67**	3 4 2 5 6 10**

CONDITIONS

Grades Held Constant	df	MS	F	Scheffe#
2	2	5359.55	38.01**	A_2V_3 A_1V_3 A_3V_3**
3	2	1825.21	12.94**	A_2V_3 A_1V_3 A_3V_3*
4	2	1183.56	8.39**	A_2V_3 A_1V_3 A_3V_3*
5	2	785.91	5.57**	A_2V_3 A_1V_3 A_3V_3*
6	2	2951.51	20.93**	A_2V_3 A_1V_3 A_3V_3**
10	2	2145.48	15.22**	A_2V_3 A_1V_3 A_3V_3**

* $p < .05$; ** $p < .01$.

# Rank order, low to high. Line connects nonsignificant differences when $p = .05$ or $.01$.

Table B.5 Summary of the analyses of simple effects and of the Scheffe tests, for the three combined conditions, which have equivalent levels of meaningfulness in both modalities, and six grades.

GRADES

Condition Held Constant	df	MS	F	Scheffe#
A_1V_1	5	2768.90	18.90**	2 3 4 5 6 10**
A_2V_2	5	3009.48	20.55**	2 3 4 5 6 10*
A_3V_3	5	4114.33	28.09**	3 4 2 5 6 10**

CONDITIONS

Grades Held Constant	df	MS	F	Scheffe#
2	2	6052.31	41.32**	A_2V_2 A_1V_1 A_3V_3**
3	2	862.91	5.89**	A_2V_2 A_1V_1 A_3V_3*
4	2	1527.55	10.43**	A_2V_2 A_1V_1 A_3V_3*
5	2	3240.18	22.12**	A_2V_2 A_1V_1 A_3V_3**
6	2	4536.04	30.97**	A_2V_2 A_1V_1 A_3V_3**
10	2	3082.53	21.05**	A_2V_2 A_1V_1 A_3V_3*

* p < .05; ** p < .01.

# Rank order, low to high. Line connects nonsignificant differences when p = .05 or .01.

ITEM ANALYSIS

In any study of learning, the material used to be learned becomes a major variable. In the previous project (Gaeth, 1960) several lists were carefully standardized for equivalence whether presented visually or auditorily. At that time care was taken to develop lists which required an equivalent number of trials to learn and which produced highly similar learning curves over trials. This standardization procedure was carried out so that a subject could learn more than one list with reasonable assurance that list differences would not be a major variable. However, since the lists had been standardized for both auditory and visual presentation, the ultimate conclusions which could be drawn from auditory, visual, and even audio-visual presentations were limited. In view of the objectives of the present project, it was decided not to attempt such standardization procedures. The differences among the lists seem clear and well-defined, and the ultimate performance scores with the lists seemed predictable. However, the finding that the performances were consistently as good or better with the A_1 and V_1 material than with the A_2 and V_2 material was unexpected. Therefore, in an effort to get more information about the lists themselves, a series of analyses were carried out.

As has been mentioned in various parts of the report itself, other researchers have demonstrated that variations in the response member of the pair has greater influence upon the performance than variations in the stimulus member. The letters of the alphabet used as response items were selected because they appeared to have a minimum of visual or auditory similarity. No effort was made to make the selection on the basis of the frequency of occurrence of the various letters in the language; instead, it was assumed they were all thoroughly familiar to children who could read and write.

The mean number of correct responses made to each of the six stimulus-response pairs was tallied and computed for selected conditions. For each condition and for the separate grades utilized, a Treatments-by-Subjects design (Lindquist, 1953) was employed and the appropriate analysis of variance performed. In all the analyses carried out, both the effects of items and of subjects were significant. Therefore, the Scheffe procedure was utilized to isolate the items which differed significantly from each other. In the presentation of the data, only the mean number of correct responses and the indications of significant differences among items are presented.

Table C.1 presents the mean correct responses made to each pair on Condition A_1 for the fourth and tenth grades. It is clear that the fourth-grade children made many more correct responses to the stimuli associated with H and with X than with the other pairs. Furthermore, the spread of the mean correct responses was great, extending from 1.3 up to 6.1. The ranking of the six items was approximately the same for the tenth grade; however, the spread between the lowest mean correct score and the highest was considerably less.

Similar analyses were carried out for Condition V_1 for the fourth and tenth grades. Table C.2 presents the results of these tallies and shows differences which are significant. The fact that the response

Table C.1 Summary of the Scheffe tests* on mean correct responses for each of the six S-R pairs on the A_1 lists for the fourth and tenth grades

Grade	Pairs					
	F	M	V	L	X	H
4	1.3	2.2	2.6	3.2	5.0	6.1
	M	F	V	L	X	H
10	4.9	5.0	5.9	7.5	7.6	8.5

* Lines connect nonsignificant differences at p = .01.

letter itself probably was not a major variable is illustrated by comparing Tables C.1 and C.2. For Condition A_1 the pairs involving X were ranked second highest in terms of mean correct responses and F was either the lowest or next to the lowest rank. In contrast, in Condition V_1 the pair including F ranked first for both grades and X ranked lowest.

Table C.2 Summary of the Scheffe tests* on mean correct responses for each of the six S-R pairs on the V_1 lists for the fourth and tenth grades.

Grade	Pairs					
	X	L	M	H	V	F
4	2.5	2.7	2.8	3.1	3.9	4.8
	X	M	V	H	L	F
10	6.5	6.7	7.1	7.5	7.6	7.9

* Lines connect nonsignificant differences at p = .01.

It is also clear that the basic performance was different for both grades on the two conditions. For the tenth grade the difference for the score for F, the highest score, and X, the lowest score, was only 1.4 while the difference between the highest and lowest scores for A_1 in the tenth grade was 3.6. Similarly, in the fourth grade the difference between the highest and lowest items for Condition V_1 was 2.3 while for Condition A_1 it was 4.8.

The obvious difference in performance related to the two conditions under consideration here is that the scores under Condition A_1 were heavily loaded with correct responses to the H and X pairings, especially for the fourth grade, while the correct responses under Conditions V_1 were more equally divided among the six items.

Table C.3 presents a series of item analyses carried out on certain selected conditions for grades 4, 5, 6, and 10. It is interesting to examine the results for grade 4 on Condition A_1V_1. Under Condition A_1 the pairing involving H was highest and the pairing involving F was lowest. However, under Condition V_1 the pairing involving F was highest. Where the two sets of materials were combined in Conditions A_1V_1, H and F occupy the two highest ranks. Clearly, there was some kind of interaction in the combined presentation.

Since the data for Conditions A_1, V_1, and A_1V_1 were gathered from independent groups, there was no direct way to search for why F was high on V_1 and on A_1V_1, while it was low in A_1. However, in some instances both an eleventh and a twelfth trial was administered. In such cases, if the eleventh trial was auditory only, then the twelfth trial was visual only. One of the samples involved in the item analysis of A_1V_1

Table C.3 Summary of the Scheffe tests* on mean correct responses for each of the six S-R pairs on the combined conditions, by grades.

Condition	Grade	Pairs					
A_1V_1	4	M	V	L	X	F	H
		3.9	4.1	4.4	4.8	5.5	5.6
	5	M	X	V	L	F	H
		4.1	4.8	5.0	5.2	5.4	5.7
	6	M	V	F	X	L	H
		4.7	4.8	5.4	5.7	6.5	6.6
A_1V_2	4	F	M	V	L	X	H
		2.8	3.0	3.6	3.8	4.6	5.3
	10	F	M	V	X	L	H
		6.3	6.4	6.9	7.4	7.9	7.9
A_2V_1	10	H	X	V	M	L	F
		6.8	6.8	7.2	7.4	7.5	8.1
A_3V_1	4	V	M	X	L	F	H
		5.6	5.9	6.1	6.5	6.8	7.5
A_3V_2	4	L	V	M	X	H	F
		4.5	5.0	5.2	5.6	6.0	6.3

* Lines connect nonsignificant differences at $p = .01$

Table C.4 Summary of the Scheffe tests* on mean correct responses for each of the six S-R pairs on single conditions, by grades.

Condition	Grade	Pairs					
A_1	4	F	M	V	L	X	H
		1.3	2.2	2.6	3.2	5.0	6.1
	10	M	F	V	L	X	H
		4.9	5.0	5.9	7.5	7.6	8.5
A_2	4	F	M	V	H	L	X
		2.0	2.6	2.7	2.7	3.5	3.9
	10	F	X	M	V	L	H
		4.5	4.7	5.1	5.4	6.7	6.9
A_3	4	M	V	L	F	X	H
		4.8	5.1	5.4	5.5	6.4	6.5
V_1	4	X	L	M	H	V	F
		2.5	2.7	2.8	3.1	3.9	4.8
	10	X	M	V	H	L	F
		6.5	6.7	7.1	7.5	7.6	7.9
V_2	4	F	M	X	H	L	V
		3.2	3.4	4.0	4.2	4.3	4.4
	10	F	M	X	H	L	V
		5.9	6.3	6.6	7.3	7.6	7.6

* Lines connect nonsignificant differences at p = .01.

for the fourth grade had twelve trials. The data were examined to determine the responses involving F on the tenth combined trial, the eleventh auditory, and the twelfth visual trial. Twenty-eight of the 34 subjects made a correct response with F on the tenth trial. Thirteen responded correctly with F on both the ensuing auditory (eleventh) and the visual (twelfth) trials. No subject responded correctly with F on the auditory trial who did not also get it correct on the visual trial, but 17 subjects, including 2 who missed the item in the tenth trial, used F correctly on the visual trial but not on the auditory. This suggests that some normal subjects may switch their use of modalities within a list to take advantage of the easier of the components.

One of the unexpected results of the present investigation was that the A_2 and V_2 material did not produce scores that were higher than the A_1 and V_1 material. Table C.4 presents the analyses carried out on the single conditions for certain grades. A comparison of the item analyses carried out on the pairs of conditions reveals that the performance with auditory nonmeaningful-nonverbal material was quite different from the performance on the nonmeaningful-verbal material. However, the comparison between Condition V_1 and V_2 does not reveal these dramatic differences.

Further research is underway in which attempts will be made to control the effects upon lists and the ultimate effect upon verbalness, meaningfulness, and bimodal versus unimodal presentation.